STREAM HABITAT ASSESSMENT FOR THE CITY OF DUVALL, WASHINGTON

Existing Conditions Report

Prepared for

City of Duvall Planning Department

April 2006

STREAM HABITAT ASSESSMENT FOR THE CITY OF DUVALL, WASHINGTON

Existing Conditions Report

Prepared for

City of Duvall Planning Department
15535 Main Street NE
Duvall, Washington 98019

Prepared by

Herrera Environmental Consultants, Inc.
2200 Sixth Avenue, Suite 601
Seattle, Washington 98121
Telephone: 206/441-9080

April 11, 2006

Contents

Tables

Figures

Introduction

This stream habitat assessment was prepared for the City of Duvall to document existing fish habitat conditions in four streams (Thayer Creek, Coe-Clemons Creek, Cherry Creek tributary A, and Cherry Creek tributary B) that are located within the City's jurisdiction. The purpose of this stream habitat assessment is to document existing fish habitat and usage in these four streams and to recommend restoration projects for improving fish habitat. The streams originate within the City of Duvall and are tributaries to the Snoqualmie River. In order to comply with Endangered Species Act (ESA) requirements for protecting salmon habitat in their jurisdiction, the City of Duvall Planning Department has received grant funding to inventory fish habitat in these four streams. This information will be used to protect listed fish species in these four streams that the City of Duvall has jurisdiction over.

Project Location

The four streams that were surveyed for this project are located in the City of Duvall, in northeast King County, Washington (Figures 1 and 2). These four streams are tributaries to the Snoqualmie River. The four streams are located in: sections 12, 13, and 24; township 26 north; range 6 east; and sections 6, 7, and 18; township 26 north; range 7 east (USGS 1968 and 1973).

The study area for Thayer Creek extends southeast from its confluence with the Snoqualmie River to its headwaters near Big Rock Road. Coe-Clemons Creek extends east from its confluence with the Snoqualmie River to its headwaters near 275th Avenue NE. The Cherry Creek tributary A study area extends south from NE Cherry Valley Road to its headwaters near NE 152nd Street. The Cherry Creek tributary B channel extends south from NE Cherry Valley Road to the north city limits.

Study Objectives

This stream habitat assessment was prepared for the City of Duvall to document existing fish habitat and usage in four streams that originate within the City. Specific objectives of this work were to:

- Conduct a background review of existing data on the four streams from literature sources, maps, aerial photographs, and information provided by the City of Duvall. Review data collected by Washington Trout on fish distribution and culverts that form migration barriers in these four streams.
- Consult with regulatory agencies to gather additional information on fish populations in these four streams.

- Conduct King County Level I stream surveys on segments of these four streams that lie within the City of Duvall.

- Conduct a qualitative reconnaissance of the Cherry Creek drainage basin that occurs outside the city limits of Duvall to identify migration barriers and overall fish habitat.

- Perform population estimates to collect data on species composition, abundance, and distribution of fish in these four streams. Identify salmon and trout species, as well as non-game fish species expected to inhabit these four streams. Describe their life histories, and spawning and rearing requirements.

- Prepare maps in GIS format based on the data collected by Herrera and Washington Trout to illustrate existing habitat conditions in these four streams. This work involves providing detailed maps of each creek that identify the drainage configuration, habitat conditions, migration barriers, fish distribution patterns, and potential restoration sites.

- Summarize the data collected from the background review, agency correspondence, stream surveys, and population estimates to describe existing fish habitat conditions in the four streams within the City of Duvall.

- Provide a list of potential restoration projects that could be undertaken in all four streams to improve fish habitat.

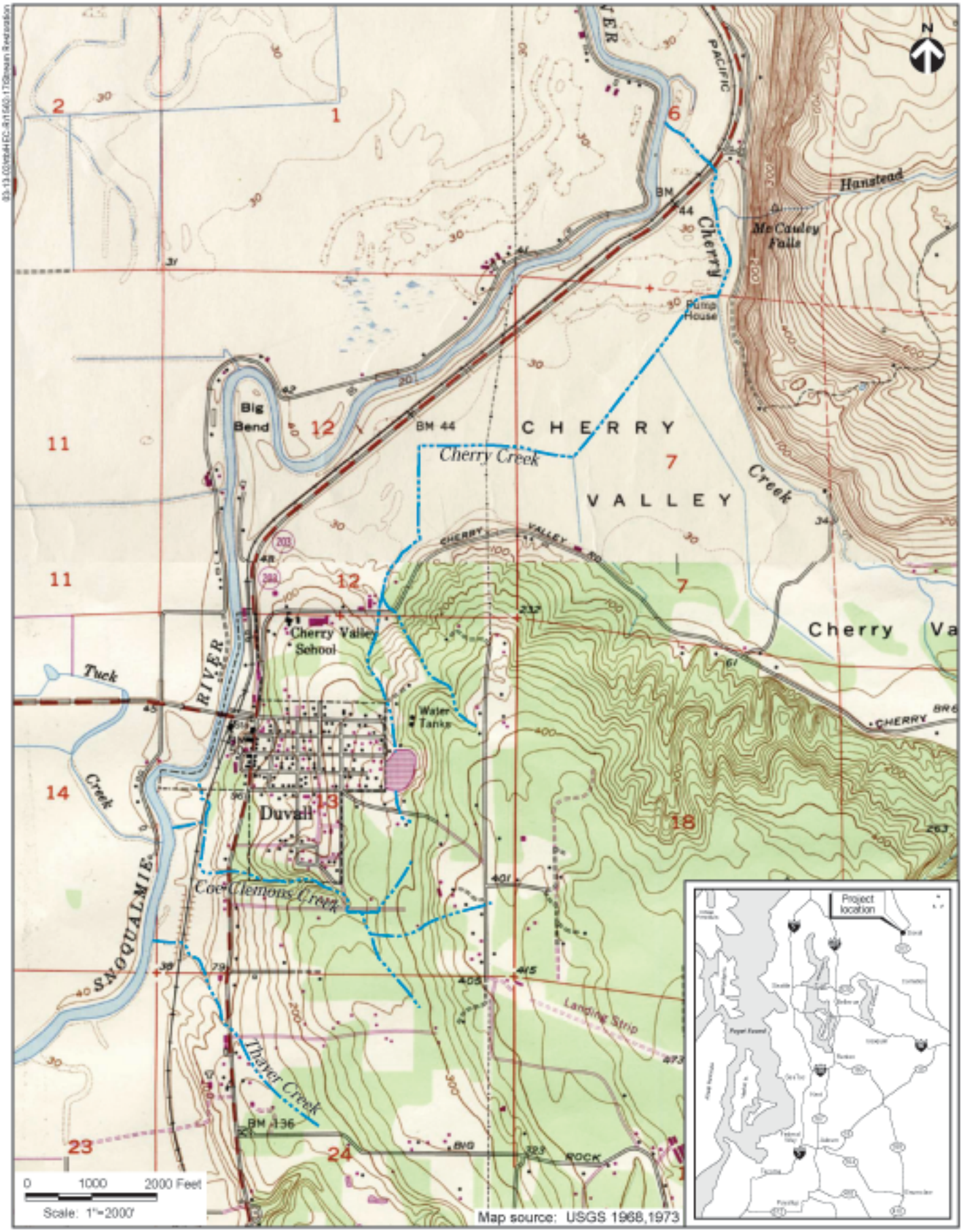

Figure 1. USGS topographic map of Duvall, Washington.

Figure 1 second page.

Figure 2. Location of streams in Duvall, Washington.

Methods and Materials

The methods and materials used to document existing conditions in the four streams within the City of Duvall involved reviewing existing background data, conducting stream surveys, and performing culvert assessments, all of which are described below.

Review of Existing Background Information

A literature review was performed to identify potential fish habitat and usage in the four streams prior to on-site field observations. Information collected specifically for this stream habitat assessment includes:

- Topographic maps of the City of Duvall project area (USGS 1968 and 1973)
- National Wetland Inventory maps of wetland areas within the project area (USFWS 1973 and 1983)
- The Soil Conservation Service soil survey map and soils descriptions for the project area (USDA 1973)
- Descriptions of watersheds, stream numbering and names, and fish usage in the project area (WDF 1975)
- The *King County Sensitive Areas Map Folio* (King County 1990) and *King County Wetlands Inventory* (King County 1991a) showing wetlands in the project area
- Water type maps from the Washington Department of Natural Resources (DNR 2001)
- Floodplain maps of the project area from the Federal Emergency Management Agency (FEMA 1995)
- Aerial photographs of the project area (DNR 1995)
- Sensitive areas maps of wetlands, streams, and 100-year floodplains in the City of Duvall (Duvall 1991)
- Zoning map of the City of Duvall showing city boundaries and land uses (Duvall 2000)

- Species lists from the U.S. Fish and Wildlife Service (USFWS) on endangered, threatened, and candidate species of fish and wildlife that may occur in the project area (USFWS 2002)

- Information from the National Marine Fisheries Service (NMFS) on endangered, threatened, and candidate species of fish that may occur within the project area (NMFS 2002)

- Washington Department of Fish and Wildlife (WDFW) Priority Habitat and Species Program maps and listing of wetlands, fish species, and wildlife species in the project area (WDFW 2001)

- Fisheries data collected by Washington Trout from culvert assessments and population estimates on the four streams within the project area (Washington Trout 2001).

Stream Surveys

King County Level 1 stream surveys were conducted in the four City of Duvall streams. These stream surveys were conducted on six dates: November 27, December 11, and December 18, 2001; and January 15, January 18, and January 23, 2002. The surveys consisted of a stream habitat inventory performed according to methodology developed by King County (1991b), as adapted from the U.S. Forest Service (McCain et al. 1990). These surveys started at the downstream edge of the study area and proceeded to the upstream edge of the study area. All descriptions of stream banks are oriented facing upstream. The stream bed was categorized and divided into reaches based on 22 habitat types (such as riffles, pools, and runs) that are defined in Table 1.

Quantitative measurements of stream channel dimensions (length, width, and depth) were taken at a locations where any of these 22 habitat types were found. Because measurements were made on a specific date, they may not be applicable at other times of year. The length of each habitat type was measured to the nearest 0.1 foot using a hip chain spool. The wetted width of the channel was measured to the nearest 0.1 foot by averaging several readings using a survey rod. The wetted depth of the channel was measured to the nearest 0.1 foot by averaging several readings using a survey rod. Average channel width was estimated based on evidence of high water marks on each bank, such as signs of bank scouring and drift lines. The average channel depth at the high water mark was also estimated. The vertical distance from the flood line to the water surface was added to the wetted depth to estimate channel depth.

Streamside structure was assessed to determine the quality and quantity of riparian vegetation on each bank. The six categories of streamside vegetation are: no riparian zone, mature forest, immature forest, shrub-dominated, grassland/pasture, and wetland. The dominant tree types in the forested categories include: coniferous, deciduous, and a mixture of both. Estimates were recorded of the dominant plant community on each bank. Adjacent wetlands within the project

Table 1. Description of Habitat Types for King County Level I Stream Surveys.

Habitat No.	Habitat Type	Description
1	Low Gradient Riffles	Shallow reaches with swiftly flowing water over partially exposed substrate. Gradient < 4 percent and substrate is usually cobble dominated.
2	High Gradient Riffles	Steep reaches of moderately deep, swift and turbulent water, with relatively more exposed substrate. Gradient is > 4 percent and substrate is boulder dominated.
3	Cascades	The steepest riffle habitat, consisting of alternating small waterfalls and shallow pools. Substrate is usually bedrock and boulders.
4	Glide	A wide shallow pool flowing smoothly with low to moderate velocities and little surface turbulence. Substrate is usually cobbles, gravel and sand.
5	Run	Swiftly flowing reaches with little surface turbulence and no major flow obstructions. Often appear as flooded riffles, with substrates such as cobbles, gravel and sand.
6	Step Run	A sequence of runs separated by short riffle steps. Substrates are usually cobble and boulder dominated.
7	Trench/Chute	Channel cross-section is typically U-shaped, formed in bedrock. Currents are swift and direction of flow is uniform.
8	Plunge Pool	Deep pools scoured as water flows over channel obstructions that creates large depressions with variable substrate.
9	Lateral Scour Pool-Log Formed	Pools formed along stream banks as the flow impinges on partial channel obstructions such as logs.
10	Lateral Scour Pools-Rootwad Formed	Pools formed along stream banks as the flow impinges on partial channel obstructions such as rootwads.
11	Lateral Scour Pools-Bedrock Formed	Pools formed along stream banks as the flow impinges on bedrock and scours substrate away.
12	Lateral Scour Pools-Boulder Formed	Pools formed by eddies around boulders as the flow impinges on the boulder and scours substrate away.
13	Dammed Pool	Water impounded form channel blockages (debris jams, rock landslides, beaver dams). Substrates are typically small gravels and sand.
14	Mid-Channel Pool	Large pools formed by mid-channel scour which encompass more than 60 percent of the wetted channel. Water velocity is slow, with variable substrate.
15	Channel Confluence Pool	Large pools formed at the confluence of two or more channels. Scour can be due to plunges, lateral obstructions or down-scour at channel intersections.
16	Secondary Channel Pool	Pools formed outside average wetted channel which may dry up during the summer. Associated with gravel bars consisting of sand and silt substrates.
17	Backwater Pool-Boulder Formed	Pools formed by eddies around boulders with shallow depth and fine-grain substrates.
18	Backwater Pool-Rootwad Formed	Pools formed by eddies around rootwads with shallow depth and fine-grained substrates.
19	Backwater Pool-Log Formed	Pools formed by eddies around logs with shallow depth and fine-grained substrates.
20	Edgewater	Quiet, shallow area found along stream banks, typically associated with riffles. Water velocity is low, and substrate varies form cobbles to boulders.
21	Pocket Water	A section of swift-flowing stream with numerous boulders or other large obstructions which create scour holes form eddies.
22	Corner Pools	Lateral scour pools formed at a bend in the channel. These pools are common in lowland valley bottoms with unconsolidated stream banks which lack obstructions.

area were identified according to the *Corps of Engineers Wetlands Delineation Manual* (U.S. COE 1987) and were classified according to *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979).

Composition of substrate in the stream channel was evaluated to list the dominant and secondary categories. Possible substrate types include: bedrock, silt-organic, sand, small gravel (<1 inch), large gravel (1-4 inches), cobbles (4-10 inches), and boulder (>10 inches). Visual estimates of the dominant and secondary categories in each habitat type were recorded.

Large woody debris in each habitat type was described for all logs greater than 6 inches in diameter. The stability of each log was assessed using three categories: anchored, unanchored, and uncertain. The tree source of the woody debris was determined using the categories of coniferous, deciduous, and unknown. The condition of woody debris was also classified as either solid, moderate, or rotten. Based on the size and stability of the woody debris, an assessment was made of the fish cover it provides. Types of woody debris that provide cover include: jams, floating logs, stranded logs, bridges, lateral logs, weirs, and rootwads.

The pool quality index is a quantitative measure of fish habitat developed by the U.S. Forest Service (USFS 1987). Table 2 lists the pool quality index for streams of orders 1 and 2 that was used for this survey. This rating system was used to evaluate the size of pools based on their width and depth, and the amount of cover available to fish. In general, pool quality is judged excellent when the pool is wider and deeper than the average stream channel and abundant cover is present. Likewise, pools that are narrow, shallow, and exposed are rated as poor quality. This rating system assigns a numerical value from 1 to 5, with 1 being poor quality and 5 meaning excellent quality.

Photographic documentation of existing habitat conditions was taken to illustrate the stream channel and riparian vegetation at the time of the survey. However, due to low light conditions, obscuring vegetation, and narrow field of view, only representative photos were taken.

Culvert Assessments

Culvert assessments were conducted according to the *Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual* (WDFW 2000). The Level A barrier analysis method was used to assess culverts encountered during the stream surveys. The Level A analysis is used to determine whether or not a culvert is a barrier, or whether a more in-depth Level B analysis is necessary to determine the status of the culvert (WDFW 2000). This data collected by Herrera biologists for culverts within the City of Duvall, was used to supplement the data collected by Washington Trout for other culverts outside the City of Duvall, especially in the Cherry Creek drainage.

Table 2. Pool Quality Index for Streams of Orders 1 and 2.

	Description		Pool Rating
1A	Maximum pool diameter is within 10 percent of the average stream width of the study site	Go to 2A, 2B	
1B	Maximum pool diameter exceeds the average stream width of the study site by 10 percent or more	Go to 3A, 3B, 3C	
1C	Maximum pool diameter is less than the average stream width of the study site by 10 percent or more	Go to 4A, 4B, 4C	
2A	Maximum pool depth is less than 1 feet	Go to 5A, 5B	
2B	Maximum pool depth is greater than or equal to 1 feet	Go to 3A, 3B, 3C	
3A	Maximum pool depth is greater than or equal to 2 feet, regardless of cover conditions, is over 1 feet with abundant fish cover [a]		Rate 5
3B	Maximum pool depth is less than 1 feet with intermediate to abundant cover between 1 and 2 feet and lacks abundant cover		Rate 4
3C	Maximum pool depth is less than 1 feet and fish cover is rated as exposed		Rate 3
4A	Maximum pool depth is greater than or equal to 1 feet with intermediate [b] or better cover		Rate 3
4B	Maximum pool depth is less than 1 feet but fish cover is intermediate or better, or depth is greater than or equal to 1 feet with exposed cover conditions		Rate 2
4C	Maximum pool depth is less than 1 feet and pool cover is rated as exposed [c]		Rate 1
5A	Pool with intermediate to abundant cover		Rate 3
5B	Pool with exposed cover conditions		Rate 2

[a] If cover is abundant, the pool has excellent instream cover and most of the perimeter of the pool has a fish cover.
[b] If cover is intermediate, the pool has moderate instream cover and one-half of the pool perimeter has fish cover.
[c] If cover is exposed, the pool has poor instream cover and less than one-fourth of the pool perimeter has fish cover.

This culvert assessment method provided data for identifying natural and human-made barriers to fish passage. A variety of culvert parameters are capable of creating barriers to fish passage including water depth and velocity within the culvert; culvert substrate, width, and slope; and the hydraulic drop at the outlet of the culvert. Properly installed culverts must provide an adequate water depth during summer low flows and an adequate size to minimize velocities during winter and spring high flows. A culvert is considered impassable under most flow conditions if there is an absence of natural streambed material throughout the culvert, a slope greater than 1 percent, and greater than a one-foot drop at the culvert outfall.

The culvert assessments were performed by using a survey rod to measure the pipe diameter, water depth in the culvert at the outlet, plunge pool maximum depth and length, and width of the second riffle downstream of the culvert. The length of the culvert was measured by several methods depending on site conditions. In short culverts with sufficient velocity, a tennis ball attached to a measuring tape was floated through the pipe. In longer culverts with low velocities, the measuring tape was stretched across the roadway in a horizontal plane to obtain an accurate length. The slope of the culverts was calculated by determining the elevations at the inlet and outlet using a survey tripod and survey rod.

Results

The results of the background review, stream surveys, culvert assessments, and fish population estimates for Thayer Creek, Coe-Clemons Creek, Cherry Creek tributary A, and Cherry Creek tributary B are discussed below.

Analysis of Existing Background Information

Information gathered from existing literature sources, maps, and agency correspondence was reviewed to assess the historic and current presence of fish and wildlife within the City of Duvall project area. A summary of the significant findings is listed below as they pertain to fish and wildlife habitat and usage. Agency correspondence for some of this background information is included in Appendix A.

Water Resources

The project area is located within the Snoqualmie River basin (designated as water resource inventory area [WRIA] #07-0219), which drains an approximately 693 square mile area (WDF 1975). The project area is located along the lower mainstem of the Snoqualmie River between river miles 7.5 and 10.5. Elevations within the Snoqualmie River valley in the project vicinity range from 30 to 42 feet above mean sea level (USGS 1968 and 1973). According to the Washington Department of Natural Resources (DNR) water typing system, the Snoqualmie River is a Type 1 water (DNR 2001). The four streams (Thayer Creek, Coe-Clemons Creek, Cherry Creek tributary A, and Cherry Creek tributary B) that originate in the City of Duvall are located along the eastern bank of the Snoqualmie River.

The Thayer Creek drainage basin covers approximately 200 acres and consists of 4,400 feet of mainstem channel and two minor tributaries that contribute an additional 100 feet of stream length. Figure 3 illustrates the channel configuration and surrounding infrastructure within the Thayer Creek basin. Thayer Creek originates in a wetland near old Big Rock Road and flows northwest where it crosses NE 143rd Place and Highway 203. The channel continues in a northwest direction where it crosses an abandoned railroad berm (Snoqualmie Valley Trail) to its confluence with the Snoqualmie River. Elevations in the Thayer Creek basin range from 30 to 160 feet above mean sea level (USGS 1973). According to the DNR water typing system, Thayer Creek is classified as a Type 3 water downstream of Highway 203, and as a Type 4 water upstream of Highway 203 (DNR 2001).

The Coe-Clemons Creek drainage basin covers approximately 250 acres and consists of 6,990 feet of mainstem channel and two tributaries that contribute an additional 2,900 feet of stream length. Figure 4 illustrates the channel configuration and surrounding infrastructure within the Coe-Clemons Creek basin. Coe-Clemons Creek originates near 275th Avenue NE and flows southwest to NE Miller Street where it joins one of its tributaries. The mainstem channel then turns northwest and combines with another tributary near NE Kennedy Drive before crossing NE 3rd Avenue. The mainstem channel then flows west through a forested ravine adjacent to Taylor Park, crosses Highway 203, then turns north as it parallels the Snoqualmie Valley Trail. On the

west side of the Snoqualmie Valley Trail, the channel forks before flowing into the Snoqualmie River at two confluences in McCormick Park. According to the DNR water typing system, Coe-Clemons Creek is a Type 3 water (DNR 2001).

The Cherry Creek drainage basin (designated as WRIA #07-0240) is located northeast of the City of Duvall and covers approximately 50 square miles (WDF 1975). The Cherry Creek basin consists of 10 river miles of mainstem channel and 12 major tributaries that contribute an additional 31 river miles of stream length. The majority of the Cherry Creek drainage basin lies outside the project area, but two minor tributaries (designated as Cherry Creek tributaries A and B) originate on the northeast side of the City of Duvall. These two tributaries flow together outside the City of Duvall on the north side of NE Cherry Valley Road and flow northeast for approximately 1.75 miles to their confluence with the mainstem Cherry Creek at river mile 0.8.

The Cherry Creek tributary A drainage basin within the City of Duvall covers approximately 90 acres and consists of 3,278 feet of mainstem channel. Figure 5 illustrates the channel configuration and surrounding infrastructure within the Cherry Creek tributary A basin. This tributary originates from groundwater seeps near NE 152nd Street, and then flows into Rasmussen Lake where it is temporarily impounded. Cherry Creek tributary A then flows northwest out of Rasmussen Lake and crosses NE Cherry Valley Road at the jurisdictional limit of the City of Duvall. According to the DNR water typing system, Cherry Creek tributary A is a Type 3 water and Rasmussen Lake is a Type 2 water (DNR 2001).

The Cherry Creek tributary B drainage basin within the City of Duvall covers approximately 60 acres and consists of 1,429 feet of mainstem channel. Figure 5 illustrates the channel configuration and surrounding infrastructure within the Cherry Creek tributary B basin. This tributary originates from groundwater seeps near 275th Avenue NE and flows northwest until it crosses NE Cherry Valley Road at the jurisdictional limit of the City of Duvall. A tributary to Cherry Creek tributary B (designated as tributary 1) combines with the mainstem at NE Cherry Valley Road. According to the DNR water typing system, Cherry Creek tributary B is a Type 4 and 5 water (DNR 2001).

Wetlands

The National Wetlands Inventory (NWI) maps identify several riverine and palustrine wetlands within the project area (USFWS 1973 and 1983). Figure 6 illustrates the location of wetlands identified on the NWI map within the project area.

- The Snoqualmie River within the City of Duvall area is identified as a riverine lower perennial open water wetland that is intermittently exposed (R2OWZ).
- Thayer Creek is classified as a riverine, upper perennial, streambed wetland that is seasonally flooded (R4SBC). Riparian vegetation associated with Thayer Creek includes a palustrine forested wetland that is seasonally flooded (PFOC), a palustrine emergent wetland that is temporarily flooded (PEMA), and a palustrine unconsolidated bottom wetland that is permanently flooded by a diked impoundment (PUBHh).

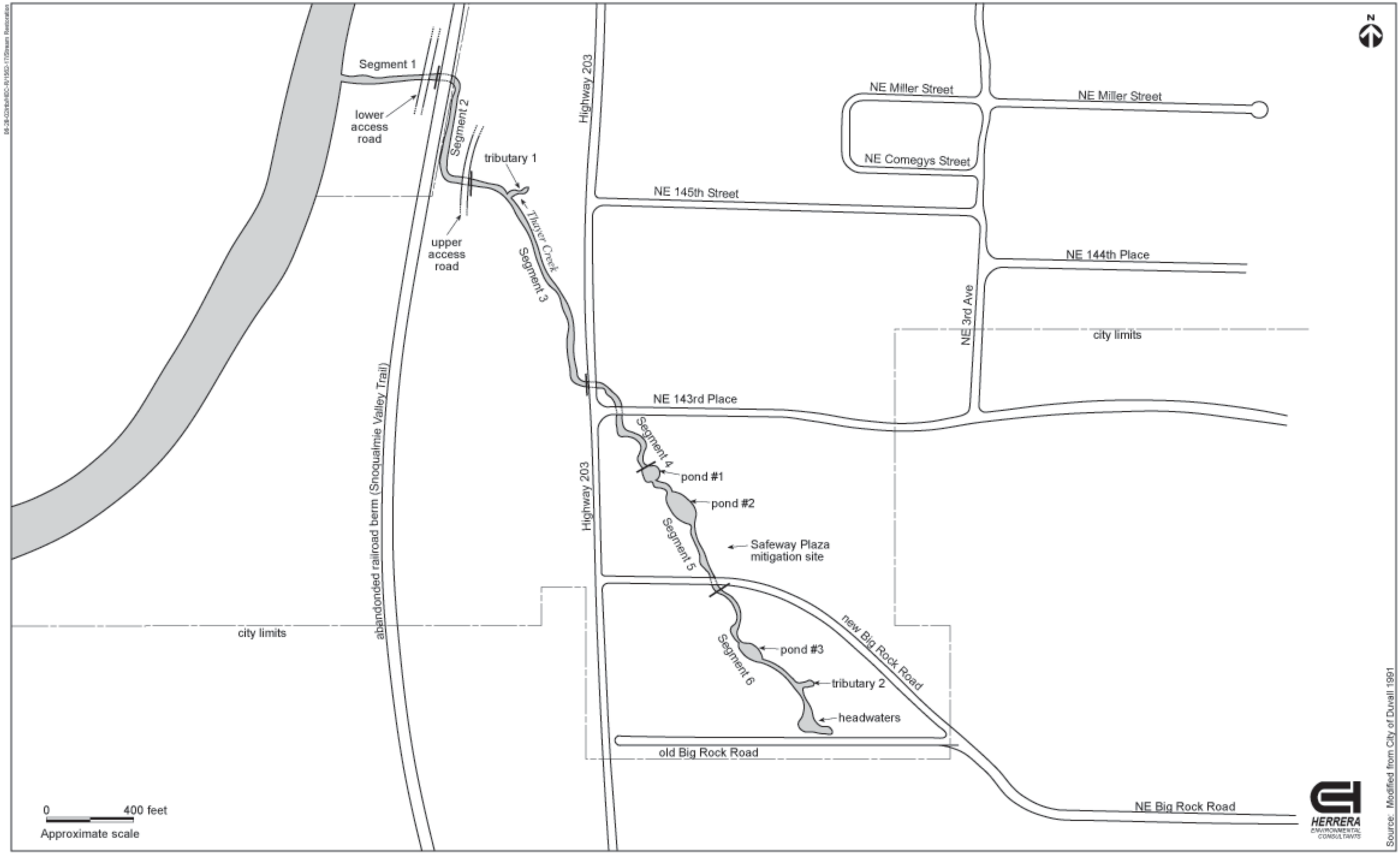

Figure 3. Channel configuration of Thayer Creek within the City of Duvall.

Figure 3 second page

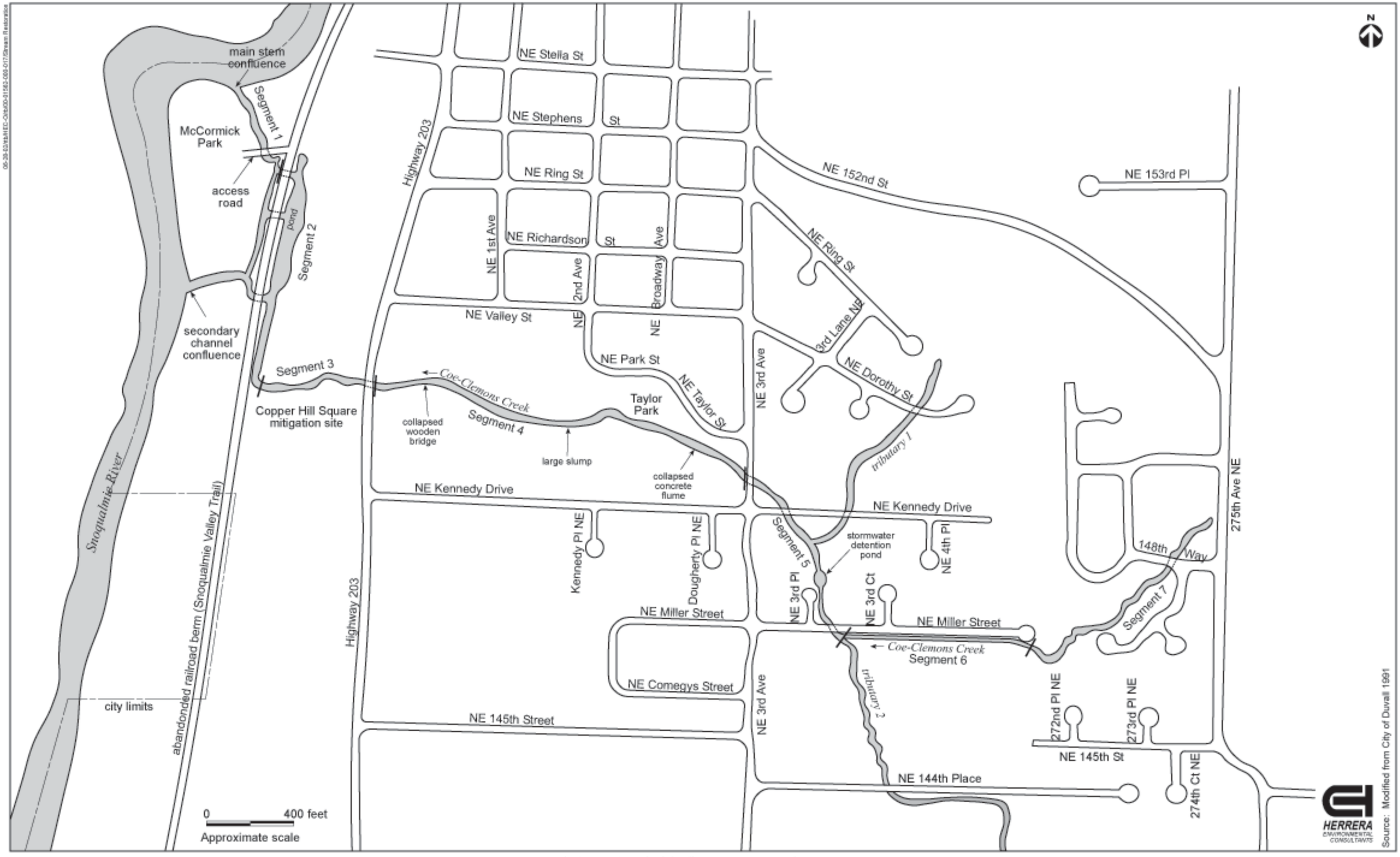

Figure 4. Channel configuration of Coe-Clemons Creek within the City of Duvall.

Figure 4 second page

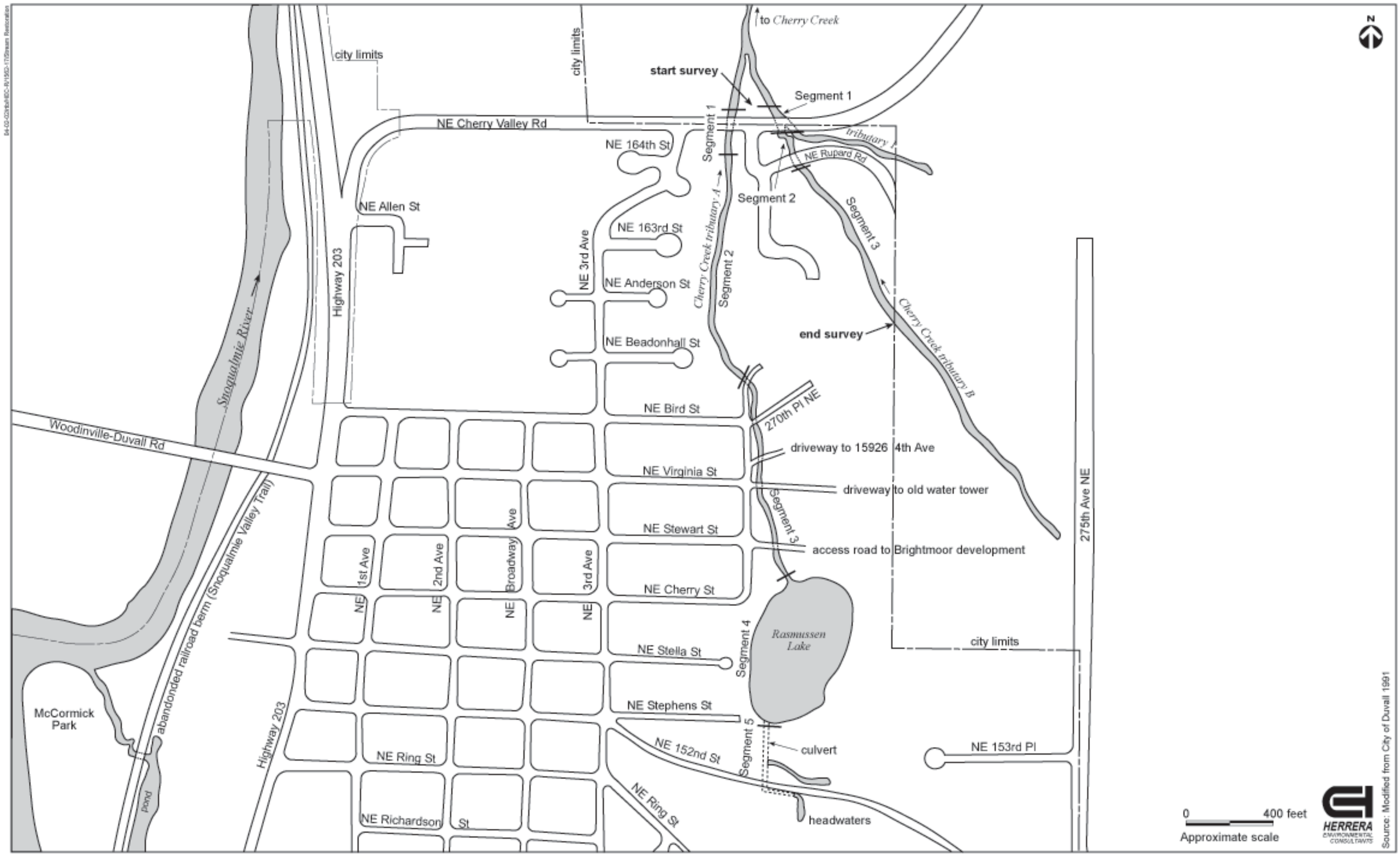

Figure 5. Channel configuration of Cherry Creek tributary A and B within the City of Duvall.

Figure 5 second page

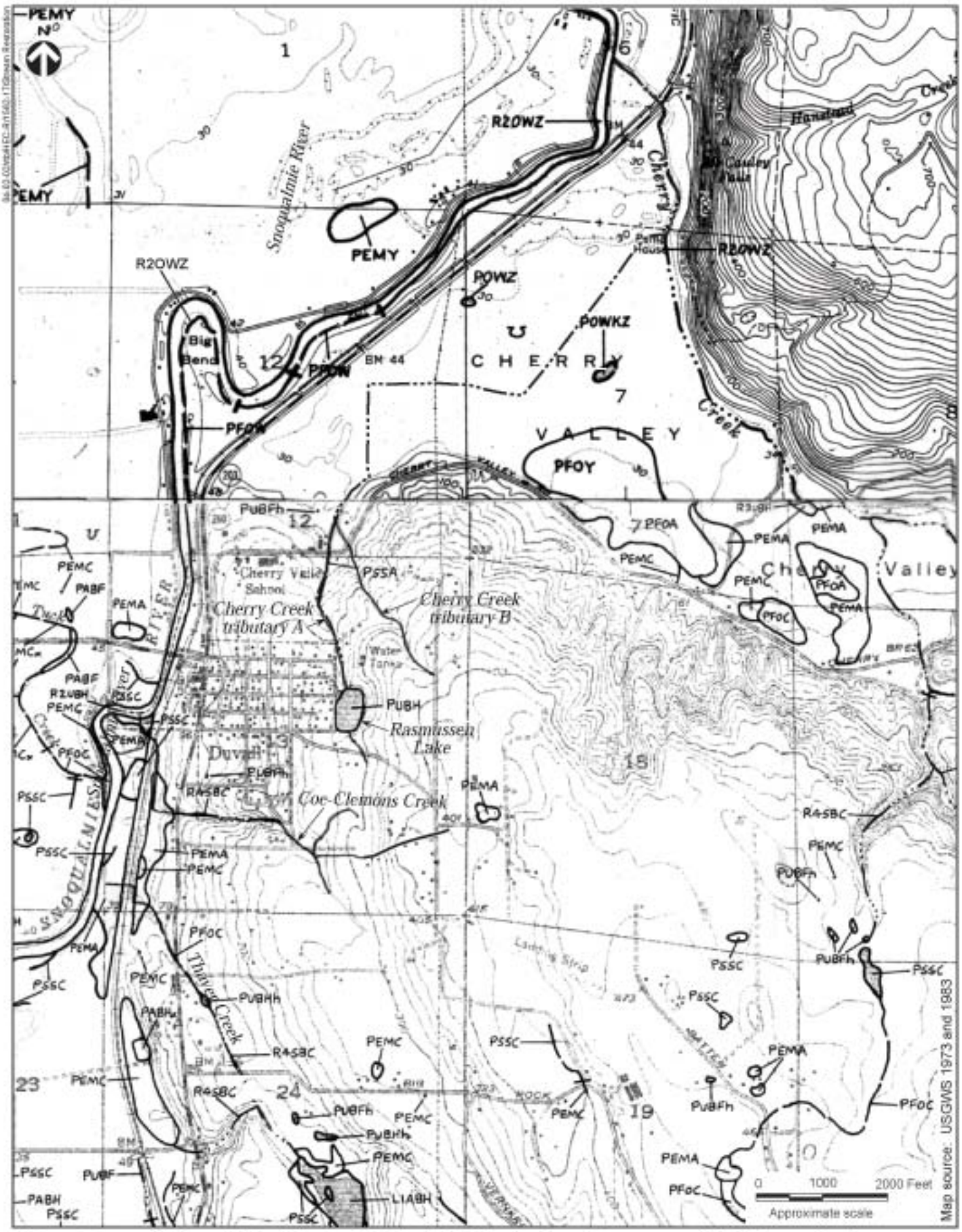

Figure 6. Wetlands identified on National Wetlands Inventory map within the project area.

- Coe-Clemons Creek is identified as a riverine, upper perennial, streambed wetland that is seasonally flooded (R4SBC). Riparian vegetation associated with Coe-Clemons Creek includes two palustrine emergent wetlands that are temporarily flooded (PEMA), and a palustrine scrub/shrub wetland that is seasonally flooded (PSSC).

- Cherry Creek tributary A is identified as a palustrine scrub/shrub wetland that is temporarily flooded (PSSA) and Rasmussen Lake is identified as a palustrine unconsolidated bottom wetland that is permanently flooded (PUBH).

The *King County Sensitive Areas Map Folio* (King County 1990) identifies several streams within the study area. The Snoqualmie River is identified as a Class 1 stream and its 100 year floodplain extends to the abandoned railroad berm (Snoqualmie Valley Trail) within the lower segment of both Thayer Creek and Coe-Clemons Creek. Thayer Creek is identified as an unclassified stream. Coe-Clemons Creek from its mouth to Taylor Park is identified as a Class 2 stream with salmonids, while its headwaters above Taylor Park is unclassified. Cherry Creek downstream of NE Cherry Valley Road is identified as a Class 2 stream with salmonids, while both Cherry Creek tributaries A and B upstream of NE Cherry Valley Road are unclassified.

The *King County Wetlands Inventory* (King County 1991a) identifies a 15.9-acre palustrine scrub/shrub and emergent wetland (Snoqualmie River #6) between Coe-Clemons Creek and Thayer Creek. This wetland, along the Snoqualmie River eastern bank, is not directly connected to either of these two stream channels. Figure 7 illustrates the location of this wetland within the project area.

Soil Descriptions

The soil survey of King County identifies five soil types in the project area, which include Briscot silt loam, Nooksack silt loam, Puget silty clay loam, Alderwood gravelly sandy loam, and Alderwood and Kitsap soils (USDA 1973). Figure 8 illustrates the soil types identified on the soil survey map within the four stream corridors.

The lower segment of Thayer Creek and Coe-Clemons Creek in the Snoqualmie River valley contains Briscot silt loam, which is considered hydric (USDA 1988). Briscot silt loam (Br) is a somewhat poorly drained soil formed in alluvium in river valleys. The soil profile to a depth of 60 inches consists of fine sandy silt loam.

The middle segment of Thayer Creek and Coe-Clemons Creek between the Snoqualmie Valley Trail and Highway 203 consists of Nooksack silt loam and Puget silty clay loam. Nooksack silt loam (Nk) is a well drained soil formed in alluvium in river valleys. The soil profile to a depth of 60 inches consists of silt loam and thin lenses of fine sandy loam. Puget silty clay loam (Pu) is a poorly drained soil formed in alluvium in river valleys, and is considered hydric (USDA 1988). The soil profile to a depth of 60 inches consists of silty clay loam.

The upper segment of Thayer Creek and Coe-Clemons Creek above Highway 203, and Cherry Creek tributary A above NE Cherry Valley Road, contains Alderwood gravelly sandy loam

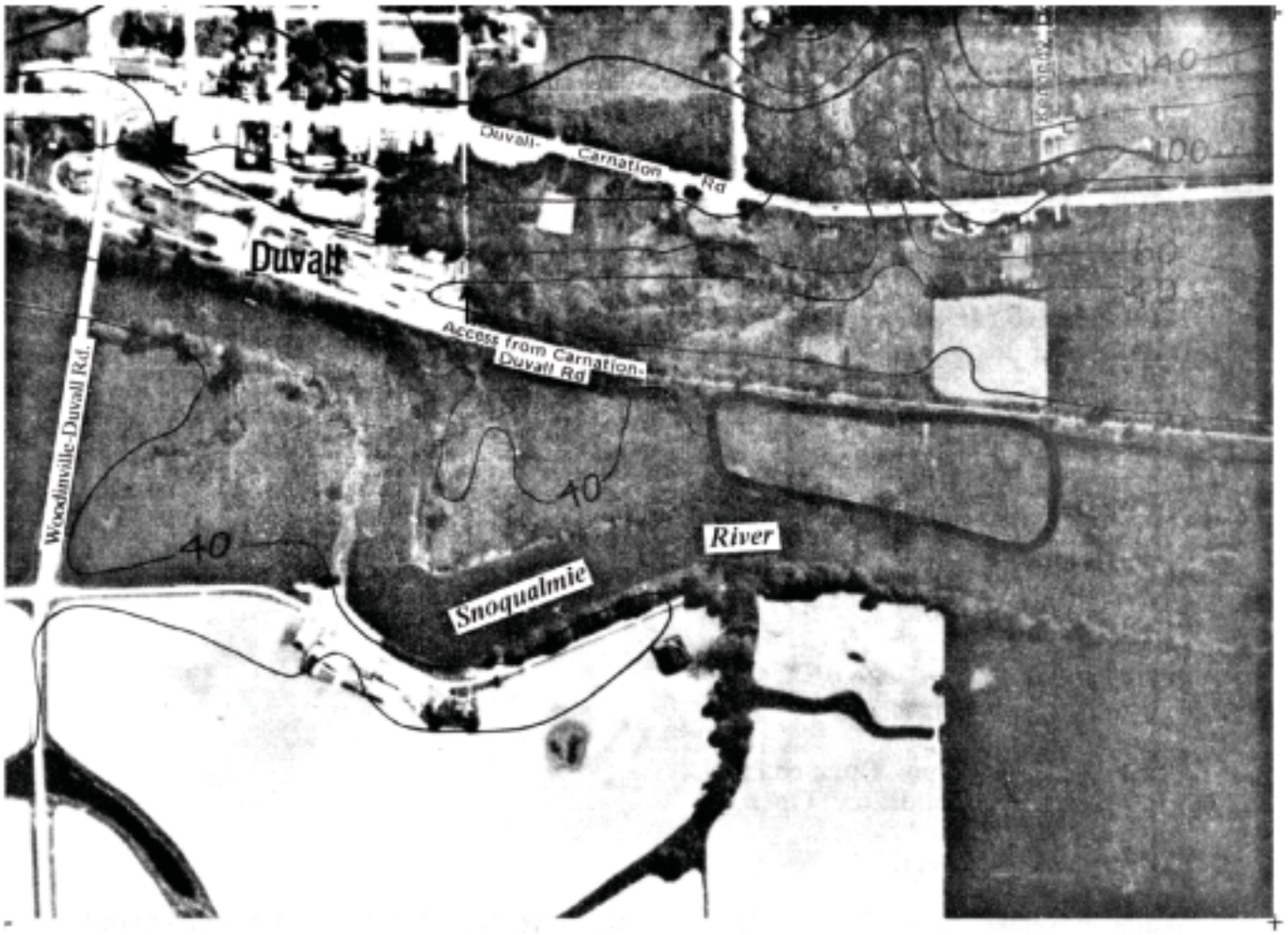

Photo Date: 05/01/80 Inventory Date: 07/22/81 N Scale: 1" = 500'

WETLAND: Snoqualmie River 6

COMMUNITY PLAN AREA: Snoqualmie

LOCATION (S,T,R): NW-SW 13, 26N, 5E
SW-SW 13, 26N, 5E

BASIN OR DRAINAGE: Snoqualmie River

ACREAGE: 15.9

SENSITIVE AREA MAP#: 7

CLASSIFICATION:	Fish & Wildlife Service	Common Name
PSS1	Palustrine Scrub-Shrub Broad-leaved Deciduous (Willow)	Scrub-Shrub
PEM5	Palustrine Emergent Narrow-leaved Persistent (Rush)	Shallow Marsh

Figure 7. Wetlands identified on King County wetland inventory map within the project area.

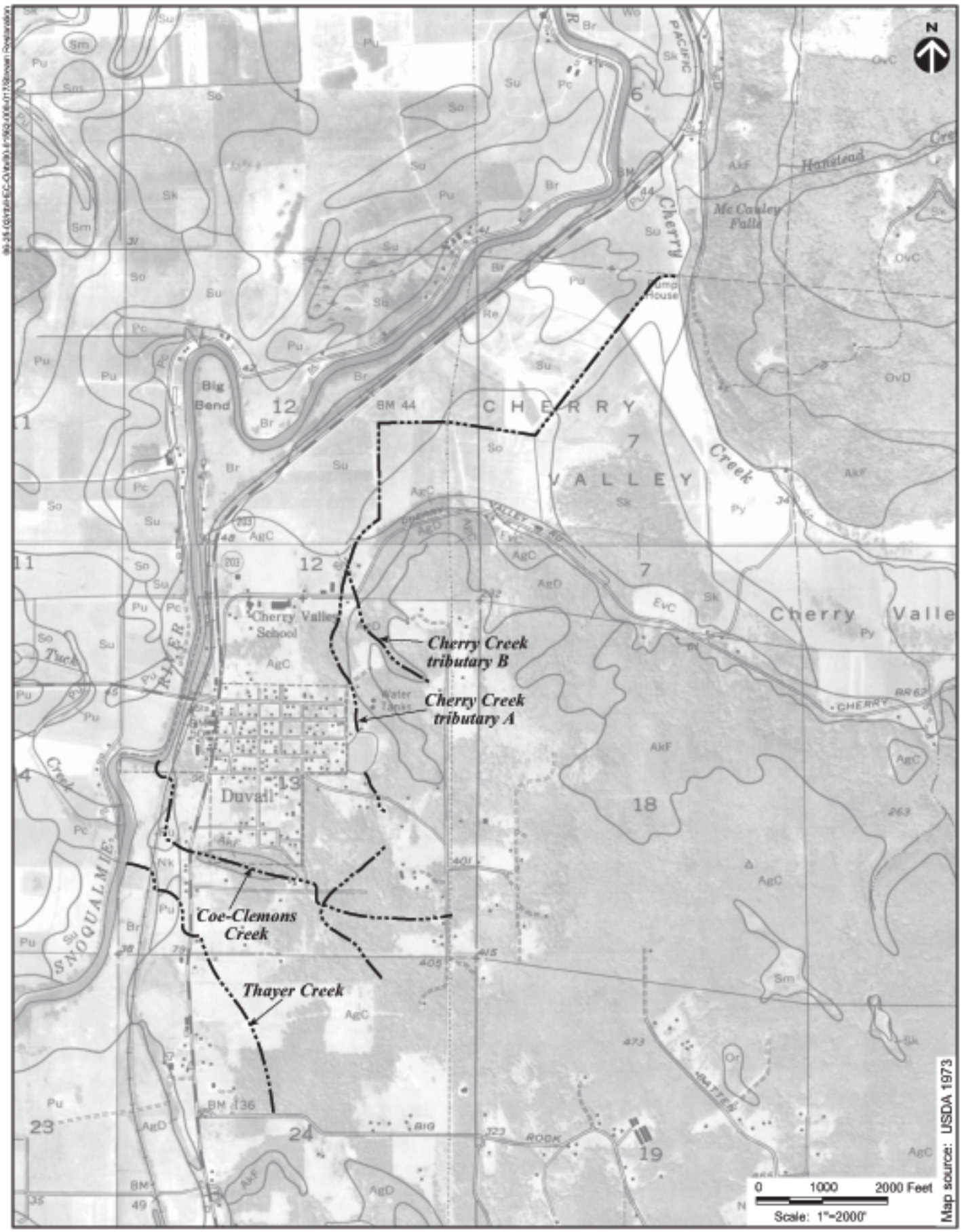

Figure 8. Soil types identified on soil survey map within the project area.

(AgC) on 6 to 15 percent slopes. Cherry Creek tributary B above NE Cherry Valley Road contains Alderwood gravelly sandy loam (AgD) on 15 to 30 percent slopes. Alderwood gravelly sandy loam is a moderately well drained soil formed from glacial deposits in upland conifer forests. The soil profile to a depth of 60 inches consists of gravelly sandy loam.

A portion of Coe-Clemons Creek between Highway 203 and 3rd Avenue NE contains Alderwood and Kitsap soils (AkF) on 25 to 70 percent slopes. This soil type consists of Alderwood gravelly sandy loam and Kitsap silt loam that have high erosion and slippage potential.

Floodplain Areas

The flood insurance rate maps for the Snoqualmie River identifies where the 100 year floodway boundary occurs within the City of Duvall (FEMA 1995). The lower segments of Thayer Creek and Coe-Clemons Creek between Highway 203 and the Snoqualmie River are within the 100- and 500-year floodway boundary.

Aerial Photograph Interpretation

Several black and white aerial photographs of the project area taken on May 18, 1995 by the Washington Department of Natural Resources were examined for vegetation patterns and land uses (DNR 1995). The majority of the Thayer Creek channel is lined by a narrow band of deciduous trees, while the headwaters near Big Rock Road consists of a larger riparian zone dominated by a mixed conifer and deciduous forest. The segment of Coe-Clemons Creek below Highway 203 is lined by a narrow band of deciduous trees, while the segment between Highway 203 and 3rd Avenue NE consists of a wide riparian zone dominated by a mixed conifer and deciduous forest. The majority of the Cherry Creek tributary A and B channels is surrounded by a broad riparian zone dominated by a mixed conifer and deciduous forest.

Endangered Fish and Wildlife Species

The U.S. Fish and Wildlife Service (USFWS) identifies a nesting territory and wintering habitat for bald eagle (*Haliaeetus leucocephalus*), a threatened species, as possibly occurring in the vicinity of the project site (USFWS 2002). The USFWS also identifies bull trout (*Salvelinus confluentus*), a threatened species, within the project vicinity. The USFWS also lists 17 species of concern that may occur in the project area. This includes two fish, two amphibian, one reptile, three bird, five mammal, three insect, and one plant species, which are listed below:

- River lamprey (*Lampetra ayresi*)
- Pacific lamprey (*Lampetra tridentata*)
- Cascades frog (*Rana cascadae*)
- Western toad (*Bufo boreas*)
- Northwestern pond turtle (*Clemmys marmorata marmorata*)
- Olive-sided flycatcher (*Contopus borealis*)
- Northern goshawk (*Accipiter gentilis*)

- Peregrine falcon (*Falco peregrinus*)
- Long-eared myotis (*Myotis evotis*)
- Long-legged myotis (*Myotis volans*)
- Pacific Townsend's big-eared bat (*Corynorhinus townsendii townsendii*)
- California wolverine (*Gulo gulo luteus*)
- Pacific fisher (*Martes pennanti pacifica*)
- Beller's ground beetle (*Agonum belleri*)
- Hatch's click beetle (*Eanus hatchi*)
- Valley silverspot (*Speyeria zerene bremeri*)
- White-top aster (*Aster curtus*)

The National Marine Fisheries Service identifies chinook salmon (*Oncorhynchus tshawytscha*), a threatened species, and coho salmon (*O. kisutch*), a candidate species as occurring in the project area (NMFS 2002).

Data from the WDFW Priority Habitat and Species Program was reviewed to identify important fish and wildlife habitat in the project area (WDFW 2001). The Snoqualmie River is identified as containing priority anadromous and resident fish. The WDFW identifies an approximately 0.2-mile-long segment of Cherry Creek tributary A upstream of NE Cherry Valley Road within the project area as containing anadromous fish and resident fish. Rasmussen Lake near the headwaters of Cherry Creek tributary A is identified as an isolated palustrine wetland. The same palustrine wetland (Snoqualmie River #6) between Coe-Clemons Creek and Thayer Creek, and identified in the *King County Wetlands Inventory* (King County 1991), is also identified by the WDFW.

Stream Survey Results for Thayer Creek

The results of the King County Level I stream habitat inventory performed on Thayer Creek are discussed below. This includes: the results of the habitat survey; and a description of the riparian soils, bank stability, channel morphology, substrate, large woody debris, pool quality, and riparian vegetation associated with Thayer Creek. The field data sheets completed for Thayer Creek are presented in Appendix B. Representative photographs taken of habitat in Thayer Creek are included in Appendix C. A summary of the culvert assessment data for Thayer Creek is provided in Appendix D.

Habitat Survey

The main stem of Thayer Creek has been divided into sixth segments (see Figure 3) based on channel gradient, migration barriers, substrate, and riparian zone conditions. The first segment (433 feet long) lies within the Snoqualmie River floodplain and extends from the confluence with the Snoqualmie River to the Snoqualmie Valley Trail. The second segment (510 feet long) extends from the Snoqualmie Valley Trail to a culvert underneath an access road (referred to as the upper access road). The third segment (1,295 feet long) extends from the upper access road to the culvert underneath Highway 203. The fourth segment (541 feet long) extends from

Highway 203 to a constructed pond (referred to as pond #1). The fifth segment (755 feet long) extends from pond #1 to the upstream side of Big Rock Road. The sixth segment (866 feet long) extends from Big Rock Road to the stream headwaters.

Table 3 lists the habitat types, channel dimensions (average width, average depth, maximum depth of pools, total length of each habitat type), and pool quality index for the main stem of Thayer Creek. A reach number is used to indicate the sequential order of habitat types observed. A total of 83 reaches were recorded over a distance of 4,400 feet from the confluence with the Snoqualmie River to the headwaters.

Proceeding upstream from the confluence with the Snoqualmie River to the Snoqualmie Valley Trail, fish habitat in the lower 433 feet of Thayer Creek has similar characteristics. The first 12 reaches consist of a series of runs, low gradient riffles, plunge pools formed by a clay layer, and dammed pools formed by small woody debris jams. The channel is confined as it flows through an incised ravine, and there is a backwater effect from the river that floods some of the lower reaches. Approximately 370 feet upstream of the mouth, there is a 26- inch-diameter steel culvert that is partially clogged (reach 13). This culvert lies underneath a dirt road (referred to as the lower access road) that provides access to farm fields on both sides of the stream. In this first segment, the average wetted stream width ranges from 2.0 to 6.2 feet, the average wetted depth ranges from 0.7 to 2.8 feet, and the maximum pool depth ranges from 1.0 to 2.7 feet.

Fish habitat within segment 2 mainly provides migration and rearing habitat. There is a 36-inch-diameter concrete culvert under the abandoned railroad berm where the Snoqualmie Valley Trail crosses Thayer Creek. The channel then turns south and parallels the eastern bank of the abandoned railroad berm for approximately 275 feet before turning east for another 156 feet to the upper access road culvert. The channel along the abandoned railroad berm (reaches 16-21) is flooded by the clogged culvert (reach 13) and provides habitat such as runs, plunge pools formed by log weirs, and dammed pools formed by small woody debris jams. The channel between the abandoned railroad berm and the upper access road culvert (reaches 22-26) has a higher gradient and is downcutting to a clay layer that forms low gradient riffles and runs. The upper access road culvert (26-inch-diameter steel pipe) is partially clogged and constricts the channel. In this second segment, the average wetted width ranges from 1.5 to 4.8 feet, the average wetted depth ranges from 0.7 to 2.5 feet, and the maximum pool depth ranges from 1.0 to 1.5 feet.

The best spawning habitat in Thayer Creek is located in segment 3 that extends 1,295 feet from the access road culvert to the culvert underneath Highway 203. The lower 210 feet of this segment (reaches 27-34) between the access road culvert and the confluence of tributary 1 consists of low gradient riffles, run, and dammed pools. Tributary 1 extends 56 feet from the north bank of the mainstem channel to a 18-inch-diameter corrugated metal pipe (CMP) culvert that extends under the City of Duvall sewage treatment plant area. The tributary 1 channel consists of low gradient riffle habitat that averages 2.2 feet wide and 0.4 feet deep. The mainstem channel upstream of the tributary 1 confluence (reaches 35-44) has a higher gradient and consists of low gradient riffle, high gradient riffle, cascade, run, and dammed pool habitat. The remaining portion of this segment up to Highway 203 (reaches 45-50) has a lower gradient and the channel is clogged with Himalayan blackberry and reed canarygrass. In segment 3, the

Table 3. Stream survey results for Thayer Creek within the City of Duvall.

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 1								
1	5	Run	5.0	2.8	–	82.0	–	Survey started at confluence with Snoqualmie River
2	1	Low gradient riffle	2.0	1.3	–	29.5	–	Incised ravine in Snoqualmie River floodplain
3	5	Run	2.5	1.4	–	13.1	–	
4	8	Plunge pool	2.5	1.5	1.9	8.2	4	
5	1	Low gradient riffle	1.8	1.3	–	8.9	–	
6	8	Plunge pool	3.6	1.4	1.7	10.5	4	
7	1	Low gradient riffle	2.5	1.8	–	9.8	–	
8	13	Dammed pool	3.8	1.9	2.5	3.3	5	
9	5	Run	3.8	0.7	–	154.5	–	
10	14	Mid-channel pool	5.0	0.9	1.0	13.8	4	
11	5	Run	5.0	1.3	–	16.1	–	
12	13	Dammed pool	6.2	2.4	2.7	19.0	5	
13	7	Trench/chute	2.7	2.5	–	18.0	–	26-inch diameter steel culvert under access road
14	5	Run	4.9	1.5	–	45.9	–	
					Total	432.6		
Segment 2								
15	7	Trench/chute	2.7	2.5	–	78.7	–	36-inch diameter circular concrete culvert under railroad berm
16	5	Run	4.2	1.0	–	151.9	–	
17	13	Dammed pool	3.7	1.2	1.4	14.1	4	
18	5	Run	4.5	0.9	–	44.9	–	
19	8	Plunge pool	4.1	0.9	1.0	12.1	4	
20	5	Run	4.8	1.1	–	49.5	–	
21	8	Plunge pool	7.0	1.1	1.5	4.9	4	Plunge pool formed by exposed pipe
22	1	Low gradient riffle	3.1	0.6	–	22.3	–	Clay layer forming waterfall
23	5	Run	2.5	1.0	–	16.7	–	
24	1	Low gradient riffle	1.5	0.7	–	17.4	–	Clay layer forming stream bottom
25	5	Run	2.5	0.9	–	76.4	–	
26	7	Trench/chute	2.7	1.0	–	21.3	–	26-inch diameter steel culvert under access road
					Total	510.2		

Table 3. Stream survey results for Thayer Creek within the City of Duvall (continued).

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 3								
27	1	Low gradient riffle	2.6	0.7	–	12.1	-	Upstream of access road culvert
28	14	Mid-channel pool	2.4	1.3	1.6	9.8	3	
29	5	Run	2.4	0.9	–	34.4	–	
30	1	Low gradient riffle	2.4	0.9	–	44.9	–	
31	13	Dammed pool	3.7	1.2	1.4	9.2	3	
32	1	Low gradient riffle	4.8	0.3	–	41.0	–	
33	13	Dammed pool	5.0	0.8	1.1	20.3	3	Tributary 1 on left bank
34	1	Low gradient riffle	3.2	0.7	–	38.7	–	Partial barrier caused by waterfall over a clay layer
35	1	Low gradient riffle	3.6	0.4	–	26.2	–	
36	13	Dammed pool	5.0	1.3	1.6	29.2	4	
37	1	Low gradient riffle	3.4	0.7	–	4.9	–	
38	13	Dammed pool	5.7	0.8	1.1	6.9	4	
39	5	Run	3.2	0.9	–	78.4	–	
40	1	Low gradient riffle	7.0	0.6	–	63.0	–	
41	8	Plunge pool	6.0	0.8	1.0	20.0	4	
42	3	Cascade	3.7	0.6	–	53.8	–	Cascades over tree roots and boulders
43	5	Run	2.9	0.7	–	24.9	–	
44	2	High gradient riffle	4.1	0.7	–	295.9	–	Cascades over boulders
45	13	Dammed pool	4.0	0.9	1.2	6.2	4	
46	1	Low gradient riffle	4.3	0.5	–	233.9	–	Channel clogged by blackberry thicket
47	14	Mid-channel pool	5.0	0.6	0.9	26.6	3	
48	1	Low gradient riffle	3.0	0.5	–	76.4	–	
49	5	Run	4.5	1.0	–	121.7	–	Channel clogged by reed canarygrass.
50	8	Plunge pool	8.0	1.1	1.5	16.4	4	Plunge pool at outlet of culvert
					Total	1,294.8		

Table 3. Stream survey results for Thayer Creek within the City of Duvall (continued).

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Total Length (ft.)	Pool Quality Index	Comments
Segment 4								
51	7	Trench/chute	1.5	0.6	–	49.2	–	24-inch circular concrete culvert underneath Highway 203
52	8	Plunge pool	2.0	1.1	1.3	6.6	2	Plunge pool from clay layer
53	1	Low gradient riffle	2.0	0.9	–	75.4	–	Exposed channel in hay pasture
54	8	Plunge pool	3.4	1.6	1.8	6.6	2	Plunge pool from clay layer
55	1	Low gradient riffle	3.8	0.6	–	42.6	–	
56	7	Trench/chute	2.5	0.6	–	59.0	–	29-inch circular concrete culvert underneath NE 143rd Place
57	5	Run	7.0	0.8	–	13.1	–	
58	1	Low gradient riffle	5.5	0.8	–	72.2	–	
59	5	Run	6.0	1.1	–	13.1	–	
60	1	Low gradient riffle	5.5	0.4	–	82.0	–	
61	5	Run	8.0	0.8	–	6.6	–	Small woody debris jams
62	1	Low gradient riffle	6.0	0.4	–	65.6	–	Channel clogged with small woody debris
63	1	Low gradient riffle	4.5	0.8	–	49.2	–	Exposed channel in emergent wetland
					Total	541.2		
Segment 5								
64	7	Trench/chute	1.5	0.4	–	19.7	–	14-inch circular plastic culvert underneath berm
65	13	Dammed pool	40.0	2.0	2.5	39.4	5	Artificial pond formed by berm
66	1	Low gradient riffle	6.0	0.9	–	72.2	–	Channel clogged by reed canarygrass
67	8	Plunge pool	4.7	1.2	1.5	6.6	2	Plunge pool at outlet of culvert
68	1	Low gradient riffle	1.0	0.3	–	23.0	–	Incised channel through berm, and 12-inch diameter concrete culvert
69	13	Dammed pool	80.0	4.0	6.0	232.9	5	Artificial pond formed by berm
70	1	Low gradient riffle	12.5	0.7	–	49.2	–	Sediment deposition from Safeway mitigation site.
71	5	Run	12.0	0.7	–	29.5	–	
72	1	Low gradient riffle	15.5	0.7	–	42.6	–	
73	1	Low gradient riffle	6.0	0.6	–	134.5	–	Emergent wetland downstream of new Big Rock Road
74	5	Run	4.5	0.8	–	65.6	–	Bottomless arch culvert underneath new Big Rock Road
75	1	Low gradient riffle	4.0	0.7	–	39.4	–	Disturbed area upstream of new Big Rock Road
					Total	754.6		

Table 3. Stream survey results for Thayer Creek within the City of Duvall (continued).

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Total Length (ft.)	Pool Quality Index	Comments
Segment 6								
76	5	Run	9.0	0.6	–	36.1	–	Within forested riparian area
77	1	Low gradient riffle	7.0	0.5	–	180.4	–	
78	7	Trench/chute	1.0	0.2	–	29.5	–	12-inch concrete circular culvert through berm and multiple seeps
79	13	Dammed pool	37.0	3.0	4	141.0	4	Artificial pond formed by berm
80	1	Low gradient riffle	6.0	0.2	–	180.4	–	Channel clogged by reed canarygrass
81	15	Channel confluence pool	3.0	0.8	1.2	6.6	1	Pool formed at confluence of tributary 2, incised through clay layer
82	1	Low gradient riffle	3.0	0.2	–	39.4	–	Incised through clay layer
83	1	Low gradient riffle	6.0	0.2	–	253.0	–	Broad swale in wetland that extends to old Big Rock Road and headwaters
					Total	866.4		

[a] Habitat types are defined in Table 1.

average wetted width ranges from 2.4 to 8.0 feet, the average wetted depth ranges from 0.4 to 1.3 feet, and the maximum pool depth ranges from 1.0 to 1.6 feet.

Segment 4 extends 541 feet between Highway 203 and an artificial pond and alternates between an open pasture, immature forest, and open pasture. There is a 24-inch-diameter concrete culvert under Highway 203, then the channel crosses through the corner of a pasture (reaches 52-55) that provides low gradient riffle and plunge pool habitat due to downcutting to a clay layer. Underneath NE 143rd Place there is a 30-inch-diameter concrete culvert, then the channel enters a forested area (reaches 57-59) that provides the last spawning habitat in the system. The channel then braids through a dense thicket of shrubs (reaches 60-62) that provides low gradient riffle and run habitat. The last reach (63) of segment 4 between the shrub thicket and an artificial pond consists of an incised channel through reed canarygrass. In this fourth segment, the average wetted width ranges from 1.5 to 8.0 feet, the average wetted depth ranges from 0.4 to 1.6 feet, and the maximum pool depth ranges from 1.3 to 1.8 feet.

Segment 5 extends 755 feet from an artificial pond to the upstream side of new Big Rock Road has been significantly altered by construction of two artificial ponds, a wetland mitigation site for the Safeway Plaza development, and the relocation of Big Rock Road. The first artificial pond (reaches 64-65) is formed by a six-foot-high earthen berm that impounds a 40 foot-wide by 2.5-foot-deep pond. The 14-inch-diameter plastic pipe that passes through this berm is undersized and a migration barrier. Approximately 80 feet upstream of this first pond there is another earthen berm that creates a second pond (reaches 66-69) that is larger (80-feet-wide, 233-feet-long, and 6-feet-deep). The earthen berm that impounds this second pond has been breached by a 1-foot-wide trench that makes obsolete the 1-foot-diameter concrete culvert that historically drained this pond. Upstream of the second pond (reaches 70-73), the channel parallels a wetland mitigation site created for the Safeway Plaza development that has contributed a substantial volume of sediment. The channel then passes underneath new Big Rock Road in a 4.5-foot-wide bottomless arch culvert (reaches 74-75) that has been disturbed by the culvert installation. The channel dimensions in segment 5 (excluding two ponds), includes an average wetted width ranging from 1.5 to 15.5 feet, and an average wetted depth ranging from 0.4 to 1.2 feet.

Segment 6 extends 866 feet from the upstream side of the new Big Rock Road to the headwaters. The lower 216 feet of this segment (reaches 76-77) consists of low gradient riffle and run habitat in a wide channel. Approximately 256 feet upstream of new Big Rock Road there is a six-foot-high earthen berm that impounds a 37 foot-wide by 4-foot-deep pond (reaches 78-79). The pond drains through the berm in a 12-inch-diameter concrete culvert and numerous seeps. The channel upstream of this pond (reach 80) consists of a low gradient riffle clogged by reed canarygrass. Approximately 613 feet upstream of new Big Rock Road there is a plunge pool over a clay layer (reach 81) where tributary 2 combines with the mainstem channel. Tributary 2 consists of a 44-foot-long swale clogged by blackberries that originates from groundwater seeps. The remaining 292 feet of the mainstem channel (reaches 82-83) consists of a forested wetland that extends to the old Big Rock Road. In segment 6 (excluding the pond), the average wetted width ranges from 1.0 to 9.0 feet, the average wetted depth ranges from 0.2 to 0.8 feet, and the maximum pool depth is 1.2 feet.

Table 4 summarizes the stream survey data for Thayer Creek for the nine habitat types that were observed. This table presents the average width, average depth, total length, and percentage that each habitat type contributed out of the total length. These data indicate that the predominant habitat type in Thayer Creek consists of low gradient riffles, runs, and dammed pools. The average channel dimensions of Thayer Creek (excluding the three large ponds) ranges from 2 to 5 feet wide and 0.6 to 1.2 feet deep.

Table 4. Summary of habitat types in Thayer Creek within the City of Duvall.

Habitat Type No.	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Total Length (ft.)	Percentage of Length (percent)
1	Low gradient riffle	4.5	0.7	2030.3	46.1
2	High gradient riffle	4.1	0.7	295.9	6.7
3	Cascade	3.7	0.6	53.8	1.2
5	Run	5.0	1.0	1,074.4	24.4
7	Trench/chute	2.1	1.1	275.4	6.3
8	Plunge pool	4.6	1.2	91.9	2.1
13	Dammed pool	17.6	1.8	521.5	11.9
14	Mid-channel pool	4.1	0.9	50.2	1.1
15	Channel confluence pool	3.0	0.8	6.6	0.1
	Total			4,400	100

Riparian Soils, Bank Stability, and Channel Morphology

The soil survey of King County identifies four soil types in the Thayer Creek project area, which include Briscot silt loam, Nooksack silt loam, Puget silty clay loam, and Alderwood gravelly sandy loam (USDA 1973). Briscot silt loam is located in the first segment on the floodplain between the Snoqualmie River and the abandoned railroad berm. Nooksack silt loam and Puget silty clay loam is located in the second and third segments between the abandoned railroad berm and Highway 203. Alderwood gravelly sandy loam is identified in the upper three segments of Thayer Creek above Highway 203. The soils observed in the stream banks and streambed generally resemble these mapped soil types, although fill material exported from offsite is present in some locations.

The stream banks are generally stable in the Thayer Creek basin, although segments 1 and 3 are degrading due to artificial bed controls and steep gradient. Segment 1 (reaches 1-12) is characterized by an artificially straightened channel that is downcutting and forming incised and unstable banks. It is assumed that this segment was straightened to maximize agricultural use of this area. The culvert approximately 369 feet upstream of the mouth (reach 13) is acting as a bed control so the channel downstream of this culvert is downcutting to match the elevation of the Snoqualmie River. This downcutting has created steep banks (1:1) that are 10 to 15 feet high and unstable. Clay layers exposed in the stream bottom are acting as temporary bed controls and creating small waterfalls and plunge pools. The steep gradient (5 percent) in portions of segment 3 (reaches 34-44) is eroding the stream banks and causing downcutting to a clay layer that forms

small waterfalls. However, bed controls formed by boulders, log weirs, and tree roots are controlling some of this downcutting.

Channel morphology in Thayer Creek consists of a meandering channel confined by low banks. The thalwag (deepest portion of channel) meanders from one bank to the other as the channel changes direction and low flows are generally confined by the banks. The average gradient in segments 1 and 2 is less than 1 percent, while the gradient in the segment 3 averages 5 percent, and the gradient in the segments 4 through 6 is less than 2 percent. The width of the flood channel averages 15 feet, and the average depth of the flood channel ranges from 1 to 2 feet. The three ponds in segments 5 and 6 of Thayer Creek provide flood storage that moderate the scouring caused by stormwater runoff.

Substrate

Table 5 summarizes the substrate composition observed in Thayer Creek based on the length of each habitat type and percentage of the total length for the dominant and secondary substrates. The dominant stream channel substrate in Thayer Creek in descending order includes silt/organics, small gravel, and sand. The secondary substrate types in descending order include sand, small gravel, and cobbles. Spawning gravels in the third segment are judged fair, based on the amount of gravels and silt embeddedness.

Table 5. Substrate summary for Thayer Creek within the City of Duvall.

Substrate Code	Substrate Types	Dominant Coverage (ft.)	Secondary Coverage (ft.)	Dominant Coverage (percent)	Secondary Coverage (percent)
1	Bedrock	39.7	39.4	0.9	0.9
2	Silt/Organic	2,377.9	226.7	54.0	5.1
3	Sand	861.5	2,940.5	19.6	66.8
4	Small Gravel	961.8	819.8	21.9	18.7
5	Large Gravel	129.6	48.2	2.9	1.1
6	Cobbles	29.5	295.9	0.7	6.7
7	Boulders	0	29.5	0	0.7
	Totals	4,400	4,400	100	100

Large Woody Debris and Pool Quality

The amount of large woody debris (LWD) in the wetted channel of Thayer Creek varies throughout the basin with the greatest density in segments 3, 4, and 6. A total of 15 logs were observed for 4,400 feet of surveyed channel, but the majority of this LWD was on the banks and not providing fish cover in pools. Most of this LWD consisted of moderately rotten deciduous logs lying unanchored on the banks. This LWD formed habitat features such as lateral logs, stranded logs, bridges, and weirs. The lack of LWD in the channel is possibly due to clearing of riparian vegetation that prevents recruitment.

Pool quality indexes (PQI) were assigned for 24 pools observed in the surveyed area of Thayer Creek. These pools consisted of 9 plunge pools, 11 dammed pools, 3 mid-channel pools, and 1 channel confluence pool. Most of these pools have widths greater than 10 percent of the average stream width and are deep, but they lack woody cover. The maximum depths of these pools ranged between 0.9 and 6 feet, and most of the pools were rated with a PQI of 4. Overall, pools in the surveyed area provide fair rearing habitat because they lack LWD as cover, but the three large ponds in the fifth and sixth segments provide excellent rearing habitat.

Riparian Vegetation

The width of the riparian zone along Thayer Creek varies throughout the surveyed area, due to clearing by private property owners and adjacent land uses. Vegetation throughout the riparian zone consists of trees, shrubs, and herbaceous species in three canopy layers. In segment 1, the banks are relatively steep and the riparian zone is narrow. The southern bank in segment 1 is covered with Himalayan blackberry (*Rubus discolor*), salmonberry (*Rubus spectabilis*), and reed canarygrass (*Phalaris arundinacea*), while the northern bank has black cottonwood (*Populus balsamifera*) and red alder (*Alnus rubra*). The lower portion of segment 2 paralleling the abandoned railroad berm is lined by a immature deciduous forest of red alder, big leaf maple (*Acer macrophyllum*), Himalayan blackberry, and salmonberry, while the upstream end of segment 2 consists of a open field of reed canarygrass. Segment 3 is bordered by a relatively wide, immature deciduous forest dominated by red alder, black cottonwood, Himalayan blackberry, salmonberry, willow (*Salix* sp.), black hawthorn (*Crataegus douglasii*), and reed canarygrass.

Riparian vegetation in segment 4 consists of an open pasture and immature deciduous forest. The pasture area consists of an emergent wetland that is dominated by soft rush (*Juncus effusus*), upland grasses, and reed canarygrass, while the immature forest contains red alder, big leaf maple, Himalayan blackberry, vine maple (*Acer circinatum*), Indian plum (*Oemleria cerasiformis*), willow, and salmonberry. Segment 5 is lined by a narrow band of red alder, salmonberry, Himalayan blackberry, and reed canarygrass. Segment 6 has the widest and most diverse riparian vegetation in the Thayer Creek basin, which includes a mature mixed forest of red alder, big leaf maple, western red cedar (*Thuja plicata*), Douglas fir (*Pseudotsuga menziesii*), Himalayan blackberry, vine maple, Indian plum, willow, salmonberry, and trailing blackberry (*Rubus ursinus*). Herbaceous vegetation in segment 6 includes reed canarygrass, slough sedge (*Carex obnupta*), creeping buttercup (*Ranunculus repens*), water parsley (*Oenanthe sarmentosa*), lady fern (*Athyrium filix-femina*), skunk cabbage (*Lysichiton americanum*), and sword fern (*Polystichum munitum*).

Population Estimates Based On Observations

Adult coho salmon were observed spawning in Thayer Creek during the stream survey conducted on November 27, 2001. Herrera biologists observed eight live fish, six carcasses, and four redds. We estimate a total population size of 30 adult coho salmon using Thayer Creek based on the assumption that half of the fish using the stream were observed. These fish were observed between an access road culvert (reach 26) and the upstream side of NE 143rd Place (reach 59). The habitat downstream of the access road is not suitable for spawning (low gradient

and lacks gravel) and the habitat upstream of NE 143rd Place precludes spawning (migration barriers and lacks gravel).

Stream Survey Results for Coe-Clemons Creek

The results of the King County Level I stream habitat inventory performed on Coe-Clemons Creek are discussed below. This includes: the results of the habitat survey; and a description of the riparian soils, bank stability, channel morphology, substrate, large woody debris, pool quality, and riparian vegetation associated with Coe-Clemons Creek. The field data sheets completed for Coe-Clemons Creek are presented in Appendix B. Representative photographs taken of habitat in Coe-Clemons Creek are included in Appendix C. A summary of the culvert assessment data for Coe-Clemons Creek is provided in Appendix D.

Habitat Survey

Coe-Clemons Creek has been divided into seven segments (see Figure 4) based on gradient, artificial barriers, substrate, and riparian zone conditions. The lowest segment (499 feet long) lies within the Snoqualmie River floodplain and extends from the confluence with the Snoqualmie River to the culvert underneath the Snoqualmie Valley Trail. Segment 2 (1,089 feet long) extends from the Snoqualmie Valley Trail to a wetland mitigation site created for the Copper Hill Square development. Segment 3 (497 feet long) extends from the wetland mitigation site created for the Copper Hill Square development to the upstream end of the culvert underneath Highway 203. Segment 4 (2,037 feet long) extends from Highway 203 to NE 3rd Avenue. Segment 5 (850 feet long) extends from NE 3rd Avenue to the upstream side of the culvert underneath NE Miller Street. Segment 6 (966 feet long) extends along the south shoulder of NE Miller Street. Segment 7 (1,051 feet long) extends from NE Miller Street to the headwaters.

Table 6 lists the habitat types, channel dimensions (average width, average depth, maximum depth of pools, total length of each habitat type), and pool quality index for the main stem of Coe-Clemons Creek. A reach number is used to indicate the sequential order of habitat types. A total of 158 reaches were recorded over a distance of 6,989 feet from the confluence with the Snoqualmie River to the headwaters.

Proceeding upstream from the confluence with the Snoqualmie River to the culvert underneath the Snoqualmie Valley Trail, fish habitat in the lower 499 feet of Coe-Clemons Creek within McCormick Park has been altered by park development. The lower area (reaches 1-7) consists of a series of low gradient riffle and run habitats within deeply incised banks. The channel is confined within an incised ravine, and there is a backwater effect from the river that floods some of the lower reaches. Approximately 410 feet upstream of the mouth, there is a 36-inch diameter plastic culvert that is 62 feet long, which passes underneath an access road into McCormick Park. In between the culvert under the access road to McCormick Park and the culvert under the Snoqualmie Valley Trail there is run and plunge pool habitat (reaches 9-10). In segment 1, the

Table 6. Stream survey results for Coe-Clemons Creek within the City of Duvall.

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 1								
1	1	Low gradient riffle	2.0	0.8	–	105.0	–	Started survey at confluence with Snoqualmie River
2	1	Low gradient riffle	4.0	0.6	–	32.8	–	Upstream of footbridge within incised ravine with banks 10 feet high
3	5	Run	5.0	1.0	–	72.2	–	Incised banks 6 feet high
4	1	Low gradient riffle	4.0	0.8	–	118.1	–	
5	5	Run	6.0	0.9	–	49.2	–	Paralleling access road to McCormick Park
6	1	Low gradient riffle	6.0	0.7	–	19.7	–	
7	5	Run	8.0	0.9	–	13.1	–	Outlet of culvert lined with quarry spalls
8	7	Trench/chute	3.0	0.8	–	62.3	–	3-foot-diameter circular plastic culvert underneath access road and beginning of second segment
9	5	Run	5.0	0.9	–	19.7	–	In between the two culverts
10	8	Plunge pool	12.0	1.2	1.3	6.6	3	Plunge pool at culvert outlet
					Total	498.7		
Segment 2								
11	7	Trench/chute	3.0	3.0	–	59.0	–	3-foot-diameter circular concrete culvert underneath abandoned railroad berm
12	13	Dammed pool	125	3.5	5.0	613.4	5	Dammed pool formed by abandoned railroad berm and beavers
13	5	Dammed pool	30.0	1.3	4.0	416.5	–	Wide channel paralleling abandoned railroad berm up to Copper Hill Square mitigation site
					Total	1,088.9		
Segment 3								
14	1	Low gradient riffle	10.0	0.3	–	78.0	–	Braided channel confined by silt fence through Copper Hill Square mitigation site
15	1	Low gradient riffle	7.0	0.3	–	17.0	–	
16	5	Run	2.0	1.6	–	20.0	–	Historic channel with incised banks within Copper Hill Square mitigation site
17	1	Low gradient riffle	2.0	0.7	–	20.0	–	Incised channel with installed large woody debris
18	5	Run	3.0	0.5	–	16.4	–	Within willow thicket upstream of Copper Hill Square mitigation site

Table 6. Stream survey results for Coe-Clemons Creek within the City of Duvall (continued).

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 3 (continued)								
19	1	Low gradient riffle	3.0	0.2	–	82.0	–	Braided channel with low banks that are easily overtopped
20	15	Channel confluence pool	5.0	0.7	1.0	8.0	2	Channel confluence pool as braids recombine
21	1	Low gradient riffle	5.0	0.2	–	59.0	–	
22	12	Lateral scour pool-boulder formed	3.5	0.8	1.0	19.7	2	Boulder forms scour pool
23	1	Low gradient riffle	5.0	0.3	–	23.0	–	Banks lined with sandbags to contain flooding
24	5	Run	6.0	0.8	–	13.1	–	
25	1	Low gradient riffle	4.5	0.4	–	29.5	–	
26	5	Run	4.5	0.8	–	9.8	–	
27	1	Low gradient riffle	4.5	0.4	–	16.4	–	At outlet of culvert underneath Highway 203
28	7	Trench/chute	6.0	0.3	–	85.3	–	6-foot-wide rectangular concrete culvert underneath Highway 203 that is clogged with sediment
					Total	497.2		
Segment 4								
29	1	Low gradient riffle	4.0	0.4	–	29.5	–	Upstream of Highway 203
30	12	Lateral scour pool-boulder formed	5.5	0.5	0.8	6.6	2	Boulder forms scour pool
31	1	Low gradient riffle	4.5	0.4	–	114.8	–	Good spawning gravels
32	9	Lateral scour pool-log formed	4.5	0.6	1.0	6.6	1	Plunge pool formed by small woody debris jam
33	1	Low gradient riffle	7.0	0.3	–	88.6	–	Erosion on right bank that is 10 feet high
34	5	Run	4.0	0.6	–	9.8	–	
35	1	Low gradient riffle	7.0	0.3	–	26.2	–	
36	2	High gradient riffle	9.5	0.2	–	19.7	–	Collapsed wooden bridge is creating partial barrier
37	2	High gradient riffle	6.0	0.5	–	32.8	–	
38	8	Plunge pool	9.0	0.7	1.0	3.3	3	Plunge pool formed by log weir
39	2	High gradient riffle	7.2	0.4	–	59.0	–	
40	9	Lateral scour pool-log formed	5.0	0.8	0.9	6.6	2	Clay layer lines plunge pool
41	2	High gradient riffle	6.0	0.4	–	59.0	–	Channel forks around gravel bar
42	5	Run	3.8	0.6	–	6.6	–	
43	2	High gradient riffle	5.5	0.3	–	39.4	–	

Table 6. Stream survey results for Coe-Clemons Creek within the City of Duvall (continued).

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 4 (continued)								
44	5	Run	5.0	0.7	–	16.4	–	
45	2	High gradient riffle	6.5	0.5	–	118.1	–	Gradient steepens to 8percent
46	5	Run	5.5	0.6	–	13.1	–	
47	2	High gradient riffle	5.0	0.4	–	68.9	–	
48	10	Lateral scour pool-rootwad formed	4.5	0.6	0.8	6.6	2	Rootwad forms pool
49	2	High gradient riffle	5.0	0.4	–	49.2	–	
50	13	Dammed pool	5.0	0.8	1.1	6.6	1	Dammed pool above log weir
51	2	High gradient riffle	4.5	0.3	–	13.1	–	Channel forks around gravel bar
52	2	High gradient riffle	6.5	0.3	–	62.3	–	
53	8	Plunge pool	9.0	1.0	1.6	9.8	2	Weir forms plunge pool
54	2	High gradient riffle	6.0	0.3	–	23.0	–	
55	8	Plunge pool	6.0	0.9	1.2	6.6	2	
56	2	High gradient riffle	7.5	0.5	–	62.3	–	
57	3	Cascade	6.5	0.6	–	55.8	–	Cascades over boulders
58	3	Cascade	6.0	0.6	–	242.7	–	Large slump on right bank with many pieces of large woody debris and clay in channel, main source of sediment to downstream reaches
59	2	High gradient riffle	5.5	0.4	–	13.1	–	
60	8	Plunge pool	6.0	0.8	1.3	3.3	2	Log weir forms plunge pool
61	2	High gradient riffle	7.5	0.4	–	236.2	–	A lot of large woody debris in channel
62	8	Plunge pool	9.0	0.7	1.0	13.1	2	Two log weirs form two plunge pools in sequence.
63	2	High gradient riffle	7.0	0.4	–	78.7	–	Near huge boulder on left bank
64	8	Plunge pool	5.0	0.6	0.8	6.6	3	Log weir forms plunge pool
65	5	Run	5.5	0.6	–	16.4	–	
66	2	High gradient riffle	6.5	0.3	–	75.4	–	
67	11	Lateral scour pool-bedrock formed	4.5	0.8	1.0	13.1	–	Clay layer forms scour pool
68	3	Cascade	7.5	0.6	–	29.5	–	Gradient increases to 10percent
69	8	Plunge pool	5.0	0.8	1.1	3.3	1	Rock weir forms plunge pool
70	3	Cascade	5.5	0.6	–	45.9	–	Clay layer on stream bed and banks

Table 6. Stream survey results for Coe-Clemons Creek within the City of Duvall (continued).

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 4 (continued)								
71	8	Plunge pool	6.0	1.1	2.1	6.6	3	Rootwad forms plunge pool
72	2	High gradient riffle	5.0	0.4	–	42.6	–	Clay layer on left bank
73	3	Cascade	7.0	0.4	–	26.2	–	Concrete flume collapsed into channel is causing barrier
74	2	High gradient riffle	6.0	0.5	–	49.2	–	
75	3	Cascade	7.5	0.5	–	114.8	–	Left bank eroded paralleling NE 3rd Avenue, and a lot of large woody debris
					Total	2,037.0		
Segment 5								
76	7	Trench/chute	3.0	0.3	–	59.0	–	3-foot-diameter circular concrete culvert underneath NE 3rd Avenue with outlet clogged with log.
77	1	Low gradient riffle	5.5	0.4	–	177.1	–	Channel between NE 3rd Avenue and NE Kennedy Drive is full of large woody debris and brush.
78	8	Plunge pool	11.0	1.3	1.5	9.8	2	Plunge pool at outlet of culvert below NE Kennedy Drive
79	7	Trench/chute	2.0	0.3	–	45.9	–	2-foot-diameter CMP culvert underneath NE Kennedy Drive
80	1	Low gradient riffle	5.5	0.4	–	110.0	–	Access denied to this reach so estimated dimensions from NE Kennedy Drive
81	1	Low gradient riffle	3.5	0.3	–	11.1	–	Near footbridge over channel
82	15	Channel confluence pool	3.2	0.4	0.6	6.2	2	Channel confluence pool from tributary 1
83	1	Low gradient riffle	4.3	0.3	–	74.1	–	
84	9	Lateral scour pool-log formed	3.5	0.4	0.5	14.1	3	Log forms scour pool
85	1	Low gradient riffle	4.0	0.3	–	12.5	–	
86	9	Lateral scour pool-log formed	2.7	0.4	0.6	6.2	2	Log forms scour pool
87	1	Low gradient riffle	5.5	0.3	–	38.0	–	
88	8	Plunge pool	7.0	1.1	1.7	4.9	4	Plunge pool at outlet of culverts from stormwater detention pond near 3rd Place.
89	7	Trench/chute	2.0	0.3	–	25.0	–	Two CMP culverts (24 and 14 inch) that drain stormwater detention pond near 3rd Place NE.

Table 6. Stream survey results for Coe-Clemons Creek within the City of Duvall (continued).

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 5 (continued)								
90	13	Dammed pool	25.0	1.0	2.0	50.0	2	Stormwater detention pond
91	8	Plunge pool	3.5	1.7	2.0	7.9	5	Plunge pool at outlet of culvert near 3rd Place NE.
92	7	Trench/chute	2.7	0.4	–	81.3	–	32-inch CMP culvert near 3rd Place NE.
93	13	Dammed pool	4.0	0.4	0.7	6.9	2	Rock dam clogging inlet to culvert forms pool
94	11	Lateral scour pool-bedrock formed	2.5	0.5	0.8	6.9	2	Lateral scour along shoulder of NE Miller St.
95	12	Lateral scour pool-boulder formed	4.3	0.5	0.7	8.2	2	Boulder forms scour pool
96	1	Low gradient riffle	3.5	0.3	–	17.7	–	
97	8	Plunge pool	5.0	0.7	0.8	3.3	1	Plunge pool at outlet of culvert underneath NE Miller St.
98	7	Trench/chute	2.0	0.3	–	74.1	–	Two culverts (24- and 18-inch CMP) underneath NE Miller St.
					Total	850.2		
Segment 6								
99	1	Low gradient riffle	1.7	0.3	–	43.3	–	Upstream of culverts on south shoulder of NE Miller St. and confluence of tributary 2.
100	7	Trench/chute	1.5	0.3	–	21.3	–	18-inch CMP culvert underneath driveway
101	1	Low gradient riffle	2.0	0.3	–	10.1	–	
102	5	Run	1.8	0.4	–	9.5	–	
103	1	Low gradient riffle	1.4	0.2	–	18.4	–	
104	8	Plunge pool	1.9	0.4	0.5	3.3	1	Plunge pool at outlet of driveway culvert
105	7	Trench/chute	1.5	0.2	–	18.4	–	18-inch CMP culvert underneath driveway
106	1	Low gradient riffle	1.5	0.2	–	14.1	–	
107	5	Run	2.5	0.4	–	12.1	–	
108	1	Low gradient riffle	3.0	0.3	–	24.3	–	
109	7	Trench/chute	2.0	0.3	–	21.0	–	24-inch CMP culvert underneath driveway
110	1	Low gradient riffle	2.2	0.2	–	30.8	–	
111	7	Trench/chute	2.0	0.3	–	12.8	–	24-inch CMP culvert underneath driveway
112	1	Low gradient riffle	1.9	0.2	–	35.4	–	
113	8	Plunge pool	2.6	0.4	0.5	4.6	1	Plunge pool at outlet of driveway culvert

Table 6. Stream survey results for Coe-Clemons Creek within the City of Duvall (continued).

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 6								
114	1	Low gradient riffle	2.3	0.3	–	38.4	–	
115	7	Trench/chute	2.0	0.3	–	21.6	–	24-inch CMP culvert underneath driveway
116	1	Low gradient riffle	1.7	0.3	–	19.0	–	
117	8	Plunge pool	2.7	0.4	0.5	4.3	1	Plunge pool at rock dam
118	1	Low gradient riffle	1.8	0.4	–	5.6	–	
119	8	Plunge pool	2.5	0.4	0.8	5.9	1	Plunge pool at outlet of driveway culvert
120	1	Low gradient riffle	1.5	0.2	–	7.2	–	
121	8	Plunge pool	2.6	0.7	1.0	4.9	1	Plunge pool at rock dam
122	1	Low gradient riffle	1.7	0.2	–	6.6	–	
123	7	Trench/chute	2.0	0.2	–	20.3	–	24-inch CMP culvert underneath driveway
124	1	Low gradient riffle	3.2	0.3	–	46.6	–	
125	7	Trench/chute	2.0	0.2	–	22.0	–	24-inch CMP culvert underneath driveway
126	1	Low gradient riffle	2.3	0.3	–	48.2	–	
127	7	Trench/chute	2.0	0.2	–	19.7	–	24-inch CMP culvert underneath driveway
128	1	Low gradient riffle	2.5	0.2	–	27.9	–	
129	7	Trench/chute	2.0	0.2	–	21.0	–	24-inch CMP culvert underneath driveway
130	1	Low gradient riffle	2.6	0.3	–	22.3	–	
131	7	Trench/chute	2.0	0.2	–	146.9	–	24-inch CMP culvert underneath driveway
132	1	Low gradient riffle	2.6	0.3	–	35.1	–	
133	7	Trench/chute	2.0	0.2	–	19.0	–	24-inch CMP culvert underneath driveway
134	1	Low gradient riffle	2.4	0.3	–	26.9	–	
135	7	Trench/chute	2.0	0.2	–	41.0	–	24-inch CMP culvert underneath driveway
136	1	Low gradient riffle	2.7	0.2	–	76.4	–	Near end of NE Miller St.
					Total	966.0		
Segment 7								
137	8	Plunge pool	2.8	0.4	0.5	7.2	2	Boulder forms plunge pool
138	1	Low gradient riffle	2.6	0.2	–	17.0	–	
139	13	Dammed pool	3.4	0.4	0.5	5.6	2	Rock weir forms pool
140	2	High gradient riffle	3.0	0.3	–	12.8	–	Gradient steepens to 10percent

Table 6. Stream survey results for Coe-Clemons Creek within the City of Duvall (continued).

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 7 (continued)								
141	1	Low gradient riffle	2.7	0.3	–	8.5	–	
142	8	Plunge pool	2.7	0.4	0.7	7.2	2	Boulder forms plunge pool
143	1	Low gradient riffle	3.5	0.2	–	11.8	–	
144	8	Plunge pool	3.5	0.4	0.5	5.6	2	Log weir forms plunge pool
145	2	High gradient riffle	3.2	0.2	–	82.3	–	Channel full of large woody debris
146	12	Lateral scour pool-boulder formed	2.4	0.6	0.8	7.5	2	
147	1	Low gradient riffle	2.7	0.3	–	10.5	–	
148	13	Dammed pool	3.5	0.7	1.0	5.6	3	Pool dammed by small woody debris
149	12	Lateral scour pool-boulder formed	3.7	0.7	1.0	7.2	3	
150	2	High gradient riffle	3.5	0.3	–	63.6	–	
151	1	Low gradient riffle	3.7	0.2	–	2.3	–	
152	2	High gradient riffle	3.6	0.3	–	225.0	–	Channel forks around gravel bar and a lot of large woody debris
153	1	Low gradient riffle	2.3	0.3	–	9.5	–	
154	2	High gradient riffle	3.5	0.2	–	88.6	–	
155	1	Low gradient riffle	3.2	0.3	–	365.1	–	Braided channel
156	1	Low gradient riffle	4.0	0.3	–	59.0	–	Bottomless arch culvert underneath NE 148th Way
157	2	High gradient riffle	3.0	0.4	–	32.5	–	
158	7	Trench/chute	1.0	0.2	–	16.4	–	12-inch plastic culvert underneath 275th Avenue NE at wetland headwaters
					Total	1,050.8		

[a] Habitat types are defined in Table 1.

average wetted width ranges from 2 to 12 feet, the average wetted depth ranges from 0.6 to 1.2 feet, and the maximum pool depth is 1.3 feet.

Segment 2 of Coe-Clemons Creek includes mainstem and secondary channel habitat on both sides of the abandoned railroad berm. The mainstem of Coe-Clemons Creek passes underneath the Snoqualmie Valley Trail and parallels the east side of the Snoqualmie Valley Trail, while the secondary channel follows the western side of the Snoqualmie Valley Trail to another confluence with the Snoqualmie River. There are three locations where Coe-Clemons Creek crosses the Snoqualmie Valley Trail, which includes a 32-inch-diameter concrete culvert that the mainstem flows through (reach 11), another culvert that the secondary channel flow through, and a 30-foot-wide bridge that the secondary channel flows under. Beaver activity has obstructed flow in the secondary channel during normal conditions, but during flood events Coe-Clemons Creek can discharge into the Snoqualmie River in two locations.

The mainstem channel on the east side of the Snoqualmie Valley Trail consists of a dammed pool (reach 12) that is approximately 700 feet long, 125 feet wide, and 5 feet deep. Upstream of the bridge on the Snoqualmie Valley Trail where the secondary channel diverges, the mainstem channel narrows to form run habitat (reach 13) that averages 30 feet wide and 1.3 feet deep. Downstream of the bridge on the Snoqualmie Valley Trail the secondary channel extends 300 feet to the Snoqualmie River. The mainstem channel in segment 2 has an average wetted width ranging from 3 to 125 feet, an average wetted depth ranging from 1.3 to 3.5 feet, and a maximum pool depth of 5 feet. This segment provides excellent rearing habitat based on the pool size and abundance of large woody debris as cover.

Segment 3 extends 497 feet through a recently created wetland mitigation site and ends at the upstream side of the culvert underneath Highway 203. Excessive bedload movement from sediment sources upstream of this segment have caused the stream to breach its banks and flow through the wetland mitigation site and have clogged the culvert underneath Highway 203. Silt fences installed during construction of this mitigation site have disrupted the water and sediment movement once the banks have been breached. The lower 135 feet of segment 3 (reaches 14-17) between the Snoqualmie Valley Trail and a willow thicket consists of low gradient riffle and run habitat that braid through reed canarygrass in multiple channels. The channel within the willow thicket (reaches 18-27) consists of low gradient riffle, run, lateral scour pool, and channel confluence pool habitat in multiple braids that split around gravel bars. The culvert underneath Highway 203 consists of a rectangular concrete box 6 feet wide that is clogged with sediment so there is only 1 foot of clearance. In segment 3, the average wetted width ranges from 2.0 to 7.0 feet, the average wetted depth ranges from 0.2 to 1.6 feet, and the maximum pool depth is 1 foot.

Segment 4 between Highway 203 and NE 3rd Avenue extends 2,037 feet through a ravine surrounded by a mature mixed forest. The channel upstream of Highway 203 (reaches 29-35) consists of low gradient riffle, run, and lateral scour pool habitat that has a relatively low gradient and wide floodplain. Approximately 280 feet upstream of Highway 203 the gradient increases and the floodplain narrows as the banks become more incised. The channel in this area (reaches 36-57) consists of high gradient riffle, cascade, run, plunge pool, and lateral scour pool habitat with abundant large woody debris. Approximately 1,020 feet upstream of Highway 203 there is a large slump on the south bank (reach 58) that is constricting the flow and contributing

fine-grained sediment to the channel. This slump on the south bank is 243 feet long and 50 feet wide and contains many trees that have fallen into the channel. Further upstream there is a smaller slump on the north bank that is 50 feet long and 20 feet high that is also unstable. Upstream of the slump area the channel (reaches 59-66) is relatively stable and provides high gradient riffle, run, and plunge pool habitat with abundant large woody debris as bed controls. Approximately 1,700 feet upstream of Highway 203 the channel is downcutting to a clay layer that acts like bedrock. The channel in this area (reaches 67-72) consists of high gradient riffle, cascade, plunge pool, and lateral scour pool habitat formed by the clay layer. Approximately 1,850 feet upstream of Highway 203 there is a concrete flume that has collapsed into the channel and is obstructing the flow. The last portion of the channel in segment 4 (reaches 73-76) is confined in a narrow ravine paralleling NE 3rd Avenue that cascades over boulders. In segment 4, the average wetted width ranges from 3.8 to 9.0 feet, the average wetted depth ranges from 0.2 to 1.1 feet, and the maximum pool depth ranges from 0.8 to 2.1 feet.

Segment 5 extends 850 feet from the culvert underneath NE 3rd Avenue to the culvert underneath NE Miller Street. There is a 3-foot-diameter concrete culvert underneath NE 3rd Avenue that has a log wedged in the outlet that is obstructing flow. The channel between NE 3rd Avenue and NE Kennedy Drive (reaches 77-78) consists of low gradient riffle habitat with abundant large woody debris and a wide floodplain. The culvert underneath NE Kennedy Drive (reach 79) consists of a 2-foot-diameter CMP culvert that is 46 feet long. Approximately 120 feet upstream of NE Kennedy Drive, tributary 1 combines with the mainstem on the left bank (reach 82). Tributary 1 flows from the northeast and originates near NE Dorothy Street. The mainstem channel upstream of tributary 1 (reaches 83-88) continues another 150 feet through the backyards of residential lots to a stormwater detention facility near 3rd Place NE. This stormwater facility (reaches 89-92) consists of two culverts (18- and 24-inch-diameter CMP) and a detention pond. Upstream of the detention pond there is another culvert (32-inch-diameter CMP) that parallels 3rd Place NE. Upstream of this culvert, the channel (reaches 93-97) consists of low gradient riffle, plunge pool, lateral scour pool, and dammed pool habitat. There are two culverts (18- and 24-inch-diameter CMP) underneath NE Miller Street that are 74 feet long. The channel dimensions in segment 5 (excluding the stormwater detention facility), includes an average wetted width ranging from 2.0 to 11.0 feet, an average wetted depth ranging from 0.3 to 1.7 feet, and a maximum pool depth ranging from 0.6 to 2.0 feet.

Segment 6 extends 966 feet along the south shoulder of NE Miller Street and is fragmented by 12 culverts underneath private driveways to residential lots. At the inlet to the culvert underneath NE Miller Street, tributary 2 combines on the right bank (reach 99). Tributary 2 flows from the southeast through a mixture of residential lots and vacant fields before originating near NE 143rd Place. The mainstem channel along NE Miller Street (reaches 100-136) alternates between a 2-foot-wide drainage ditch and 2-foot-diameter CMP culverts as it parallels the residential lots. In segment 6, the average wetted width ranges from 1.4 to 3.2 feet, the average wetted depth ranges from 0.2 to 0.7 feet, and the maximum pool depth ranges from 0.5 to 1.0 feet.

Segment 7 extends 1,051 feet from NE Miller Street to the headwaters near 275th Avenue NE. The channel upstream of NE Miller Street flows through a forested ravine protected as native growth protection area. The channel for the first 1,034 feet (reaches 136-157) consists of low

gradient riffle, high gradient riffle, plunge pool, lateral scour pool, and dammed pool habitat with abundant large woody debris. There is an 18-foot-wide bottomless arch culvert underneath NE 148th Way that has been installed recently. The headwaters originate from a wetland located upstream of 275th Avenue NE that flow into a 12-inch-diameter plastic culvert that funnels the flow into a defined channel. In segment 7, the average wetted width ranges from 2.3 to 4.0 feet, the average wetted depth ranges from 0.2 to 0.7 feet, and the maximum pool depth ranges from 0.5 to 1.0 feet.

Table 7 summarizes the stream survey data for Coe-Clemons Creek for the nine habitat types that were observed. This table presents the average width, average depth, total length, and percentage that each habitat type contributed out of the total length. This data indicates that the predominant habitat consists of low gradient riffles, runs, and dammed pools. The average channel dimensions of Coe-Clemons Creek (excluding the three large ponds) ranges from 2.0 to 5.0 feet wide and 0.6 to 1.2 feet deep.

Table 7. Summary of habitat types in Coe-Clemons Creek within the City of Duvall.

Habitat Type	Average Width (ft.)	Average Depth (ft.)	Total Length (ft.)	Percentage of Length (percent)
Low gradient riffle	3.54	0.33	2,320.4	33.2
High gradient riffle	5.52	0.36	1,606.8	23.0
Cascade	6.67	0.55	514.9	7.4
Run	6.61	0.75	713.9	10.2
Trench/chute	2.27	0.41	893.3	12.8
Plunge pool	5.18	0.77	128.1	1.8
Lateral scour pool-log formed	3.92	0.55	33.5	0.5
Lateral scour pool-rootwad formed	4.50	0.6	6.6	0.1
Lateral scour pool-bedrock formed	3.50	0.65	20.0	0.3
Lateral scour pool-boulder formed	3.88	0.62	49.2	0.7
Dammed pool	27.65	1.13	688.1	9.8
Channel confluence pool	4.10	0.55	14.2	0.2
Total			6,989	100

Riparian Soils, Bank Stability, and Channel Morphology

The soil survey of King County identifies four soil types in the Coe-Clemons Creek project area, which include Briscot silt loam, Nooksack silt loam, and Puget silty clay loam, and Alderwood gravelly sandy loam (USDA 1973). Briscot silt loam is located in segment 1 on the floodplain between the Snoqualmie River and the abandoned railroad berm. Nooksack silt loam and Puget silty clay loam is located in segments 2 and 3 between the abandoned railroad berm and Highway 203. Alderwood gravelly sandy loam is identified in the segments 4 through 7 of Coe-Clemons Creek above Highway 203. There is also a portion of segment 4 that contains

Alderwood and Kitsap soils, which corresponds to the large slump (reach 58). The soils observed in the stream banks and streambed generally resemble these mapped soil types, although fill material exported from offsite is present in some locations.

The stream banks are generally stable in the Coe-Clemons Creek basin, although segments 1, 3, and 4 are degrading due to artificial bed controls and steep gradient. Segment 1 (reaches 1-3) lies within an incised ravine that is downcutting and forming steep banks (1:1) that are 10 to 15 feet high and unstable. Clay layers exposed in the stream bottom are acting as bed controls and creating small waterfalls and plunge pools. Segment 3 has a braided channel due to excessive sediment deposition from upstream sources. The steep gradient (5 percent) in portions of segment 4 (reaches 45-75) is eroding the banks and causing downcutting to a clay layer that forms small waterfalls. The large slump (reach 58) is caused by a clay layer that underlies a glacial till layer, which is prone to landslides.

Channel morphology in Coe-Clemons Creek varies from a meandering channel confined by low banks to entrenched artificially straightened channels. Segments 3, 4, 5, and 7 have relatively unconstrained channels that meander within their floodplain. Segments 1 and 6 are confined within incised channels that do not allow meandering. The stream gradient ranges from 0 percent in segment 2 to 10 percent in segment 4. The width of the flood channel averages 15 feet, and the average depth of the flood channel ranges from 1 to 2 feet. The stormwater detention pond in segment 5 of Coe-Clemons Creek provides flood storage that moderates the scouring caused by stormwater runoff.

Substrate

Table 8 summarizes the substrate composition observed in Coe-Clemons Creek based on length and percentage of the total length for the dominant and secondary substrates. The dominant stream channel substrate in Coe-Clemons Creek in descending order includes silt/organics, small gravel, and large gravel. The secondary substrate types in descending order include sand, small gravel, and large gravel. Spawning gravels in the fourth segment are judged fair, based on the size of the gravels and silt embeddedness.

Table 8. Substrate summary for Coe-Clemons Creek within the City of Duvall.

Substrate Code	Substrate Types	Dominant Coverage (ft.)	Secondary Coverage (ft.)	Dominant Coverage (percent)	Secondary Coverage (percent)
1	Bedrock	814.6	0	11.7	0
2	Silt/Organic	1,670.5	1,102.9	23.9	15.8
3	Sand	28.5	2,555.9	0.4	36.6
4	Small Gravel	1,773.7	1,499.6	25.4	21.5
5	Large Gravel	1,713.1	1,296.7	24.5	18.5
6	Cobbles	988.6	191.2	14.1	2.7
7	Boulders	0	342.7	0	4.9
Totals		6,989	6,989	100	100

Large Woody Debris and Pool Quality

The amount of large woody debris (LWD) in the wetted channel of Coe-Clemons Creek varies throughout the basin with the greatest density in segments 2, 4, 5, and 6. There are numerous logs in the beaver pond within segment 2. The forested riparian zone in segments 4, 5, and 7 also contributes many pieces of LWD to the channel. A total of 65 logs were observed in segment 4, 17 logs were observed in segment 5, and segment 7 has 20 logs. Most of this LWD consisted of moderately rotten deciduous logs lying unanchored on the banks. This LWD formed habitat features such as lateral logs, stranded logs, bridges, and weirs. The lack of LWD in segments 1, 3, and 6 is possibly due to clearing of riparian vegetation that prevents recruitment.

Pool quality indexes (PQI) were assigned for 42 pools observed in the surveyed area of Coe-Clemons Creek. These pools consisted of 22 plunge pools, 4 lateral scour pools formed by logs, 1 lateral scour pool formed by a rootwad, 2 lateral scour pools formed by bedrock (clay), 5 lateral scour pools formed by boulders, 6 dammed pools, and 2 channel confluence pools. Most of these pools have widths greater than 10 percent of the average stream width and are deep, but they lack woody cover. The maximum depths of these pools ranged between 0.9 and 6 feet, and most of the pools were rated with a PQI of 2. Overall, pools in the surveyed area provide fair rearing habitat because they lack LWD as cover, but the large pond in segment 2 provides excellent rearing habitat.

Riparian Vegetation

The width of the riparian zone along Coe-Clemons Creek varies throughout the surveyed area, due to clearing by private property owners and adjacent land uses. Vegetation throughout the riparian zone consists of trees, shrubs, and herbaceous species in three canopy layers. In segment 1, the banks are steep and the riparian zone is narrow. The banks are covered with Himalayan blackberry, salmonberry, and reed canarygrass, black cottonwood, and red alder. Segment 2 paralleling the abandoned railroad berm is lined by a riparian forest of red alder, big leaf maple, Himalayan blackberry, and salmonberry, while the pond shoreline consists of a open field of reed canarygrass, slough sedge, and soft rush. Segment 3 consists of a open field of reed canarygrass and a willow thicket.

Riparian vegetation in segment 4 consists of a mature mixed forest of red alder, big leaf maple, western red cedar, Douglas fir, Himalayan blackberry, vine maple, Indian plum, willow, and salmonberry. Segment 5 is lined by a narrow band of red alder, salmonberry, Himalayan blackberry, slough sedge, and reed canarygrass. Segment 6 has the least amount of riparian vegetation in the Thayer Creek basin, which consists of lawn grass and ornamental shrubs. Riparian vegetation in segment 7 consists of an immature mixed forest of red alder, big leaf maple, Himalayan blackberry, vine maple, Indian plum, willow, salmonberry, slough sedge, creeping buttercup, lady fern, skunk cabbage, and sword fern.

Population Estimates Based On Observations

Adult coho salmon were observed spawning in Coe-Clemons Creek during the stream surveys conducted on November 26 and 29, 2001. Herrera biologists observed six live fish, seven carcasses, and two redds. We estimate a total population size of 25 adult coho salmon using Coe-Clemons Creek based on the assumption that half of the fish using the stream were observed. These fish were observed between the Copper Hill Square wetland mitigation site (reach 14) and the upstream side of Highway 203 (reach 35). The habitat downstream of the mitigation site is not suitable for spawning (low gradient and lacks gravel) and migration barriers upstream of Highway 203 may limit spawning.

Stream Survey Results for Cherry Creek Tributary A

The results of the King County Level I stream habitat inventory performed on Cherry Creek tributary A is discussed below. This includes: the results of the habitat survey; and a description of the riparian soils, bank stability, channel morphology, substrate, large woody debris, pool quality, and riparian vegetation associated with Cherry Creek tributary A. The field data sheets completed for Cherry Creek tributary A are presented in Appendix B. Representative photographs taken of habitat in Cherry Creek tributary A are included in Appendix C. A summary of the culvert assessment data for Cherry Creek tributary A is provided in Appendix D.

Habitat Survey

The main stem of Cherry Creek tributary A has been divided into five segments (see Figure 5) based on channel gradient, migration barriers, substrate, and riparian zone conditions. The first segment (256 feet long) flows through emergent wetlands on both sides of NE Cherry Valley Road. The second segment (997 feet long) extends upstream of NE Cherry Valley Road to a culvert underneath NE 4th Avenue. The third segment (1,070 feet long) extends from the NE 4th Avenue culvert to Rasmussen Lake. The fourth segment (577 feet long) consists of Rasmussen Lake. The fifth segment (378 feet long) extends from Rasmussen Lake to the headwaters near NE 152nd Street.

Table 9 lists the habitat types, channel dimensions, and pool quality index for Cherry Creek tributary A. A reach number is used to indicate the sequential order of habitat types. A total of 65 reaches were recorded over a distance of 3,278 feet from NE Cherry Valley Road to the headwaters.

The survey of Cherry Creek tributary A started in a pasture 43 feet downstream of NE Cherry Valley Road, which is outside the City of Duvall corporate limits. Proceeding upstream to the culvert underneath NE Cherry Valley Road, fish habitat in the lower 43 feet of Cherry Creek tributary A (reaches 1-5) has similar characteristics. The first 4 reaches consist of low gradient riffle and lateral scour pools formed by a clay layer acting as bedrock. The channel is incised and narrow as it flows through an emergent wetland. At the downstream edge of NE Cherry Valley Road, there is a plunge pool (reach 5) formed by a one-foot drop from the culvert (3-foot-diameter CMP) underneath NE Cherry Valley Road. The next section of channel upstream of

NE Cherry Valley Road (reach 7) is incised as it flows over cobbles. Approximately 43 feet upstream of NE Cherry Valley Road the channel braids through a reed canarygrass field as it passes underneath a footbridge. Approximately 150 feet upstream of NE Cherry Valley Road the channel enters a forested ravine and again becomes a defined channel. In segment 1, the average wetted width ranges from 2.0 to 5.0 feet, the average wetted depth ranges from 0.2 to 0.9 feet, and the maximum pool depth ranges from 0.8 to 1.2 feet.

Segment 2 of Cherry Creek tributary A within the forested ravine between NE Cherry Valley Road and NE 4th Avenue provides the best spawning habitat within the project area. The lower 450 feet of segment 2 (reaches 9-30) has a relatively low gradient (< 5 percent) and consists of low gradient riffle, run, plunge pool, and dammed pool habitat. The channel in this lower section meanders through a narrow floodplain between the steep ravine slopes and there are several locations where the channel is downcutting to a clay layer that acts as bedrock. The upper 548 feet of segment 2 (reaches 31-41) has a higher gradient (5-10 percent) as the channel cascades over boulders and cobbles. Habitat in this upper portion consists of low gradient riffles, high gradient riffles, cascades, and dammed pools formed by the abundant woody debris in the channel. The stream banks are eroded in several locations in segment 2 as the channel meanders between the ravine slopes. In segment 2, the average wetted width ranges from 3.0 to 10.0 feet, the average wetted depth ranges from 0.2 to 0.9 feet, and the maximum pool depth ranges from 0.6 to 1.4 feet.

Segment 3 extends 1,070 feet from the NE 4th Avenue culvert to the outlet of Rasmussen Lake. There is a 150-foot-long culvert (2-foot-diameter CMP) under 4th Avenue that has a 1-foot drop into the plunge pool. Between NE 4th Avenue and 270th Place NE there is a 115-foot-long section (reaches 43-45) that provides high gradient riffle and lateral scour pool habitat. At 270th Place NE, a 13-foot-wide arch culvert has recently been installed that has disturbed the channel (reach 46). At the downstream end of the culvert replacement site there are straw bales and a silt fence that obstruct the flow, and gravel was installed inside the culvert that is trapped by baffles in the culvert bottom. At the upstream end of the culvert replacement site, the channel has been lowered by three feet, which creates a plunge pool (reach 47) and waterfall down a clay bank (reach 48) that forms a migration barrier. Upstream of the waterfall, the channel braids through a vacant lot clogged with Himalayan blackberry and reed canarygrass (reaches 49-50). Approximately 125 feet upstream of 270th Place NE, there is a private driveway crossing with a 1-foot-diameter concrete culvert that is undersized (reach 51). The next 85 feet of channel provides low gradient riffle habitat (reaches 52-54), then there is another driveway crossing with a 2-foot-diameter concrete culvert (reach 55). Upstream of this second driveway crossing, the channel has been recently restored by lining the stream bed with cobbles and clearing the banks (reach 57). The next 250 feet of channel passes through the Brightmoor development where access agreements were not obtained, and thus no survey was conducted (reach 58). However, habitat in this reach appears to be similar to reaches 52-54, and there is an 8-foot-wide bottomless arch culvert that has recently been installed. Approximately 85 feet downstream of Rasmussen Lake, there is a plunge pool at the outlet of a culvert (reach 59) with a 3-foot drop. This culvert (2-foot-diameter CMP) extends 49 feet through a berm that controls the water level in Rasmussen Lake (reach 60). In segment 3, the average wetted width ranges from 1.0 to 6.0 feet, the average wetted depth ranges from 0.2 to 0.9 feet, and the maximum pool depth ranges from 0.8 to 1.3 feet.

Table 9. Stream survey results for Cherry Creek tributary A within the City of Duvall.

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 1								
1	11	Lateral scour pool-bedrock formed	3.5	0.9	1.2	9.8	1	Started survey in pasture 43 feet downstream of NE Cherry Valley Road
2	1	Low gradient riffle	3.0	0.3	–	13.1	–	Incised channel through emergent wetland of soft rush
3	11	Lateral scour pool-bedrock formed	3.0	0.5	0.8	9.8	1	
4	1	Low gradient riffle	2.5	0.3	–	6.6	–	
5	8	Plunge pool	5.0	0.7	1.0	3.3	2	Plunge pool at outlet of culvert below NE Cherry Valley Road
6	7	Trench/chute	3.0	0.2	–	62.3	–	3-foot-diameter CMP culvert underneath NE Cherry Valley Road with 1' drop at outlet
7	1	Low gradient riffle	2.0	0.5	–	42.6	–	Incised channel over cobbles at inlet to culvert
8	1	Low gradient riffle	3.0	0.2	–	108.2	–	Braided channel clogged with reed canarygrass underneath footbridge
					Total	255.7		
Segment 2								
9	1	Low gradient riffle	3.0	0.4	–	45.9	–	Defined channel again when entering riparian forest
10	5	Run	3.5	0.4	–	13.1	–	
11	1	Low gradient riffle	3.5	0.3	–	62.3	–	
12	5	Run	7.0	0.3	–	9.8	–	
13	1	Low gradient riffle	4.0	0.3	–	19.7	–	
14	13	Dammed pool	6.5	0.4	0.8	16.4	2	Weir forms dammed pool
15	1	Low gradient riffle	4.5	0.3	–	26.2	–	
16	13	Dammed pool	5.5	0.6	0.8	19.7	2	Weir forms dammed pool full of large woody debris
17	1	Low gradient riffle	5.0	0.3	–	6.6	–	Clay layer exposed in stream bed
18	13	Dammed pool	5.0	0.6	0.8	19.7	2	Weir forms dammed pool
19	1	Low gradient riffle	3.5	0.3	–	42.6	–	Channel full of large woody debris
20	3	Cascade	5.0	0.6	–	29.5	–	Channel cascades over boulders
21	5	Run	4.5	0.4	–	9.8	–	Boulder dams flow somewhat
22	1	Low gradient riffle	4.0	0.4	–	16.4	–	Clay layer exposed in left bank
23	8	Plunge pool	5.0	0.6	0.9	9.8	2	Plunge pool formed by weir
24	1	Low gradient riffle	4.0	0.3	–	3.3	–	
25	8	Plunge pool	6.0	0.6	1.0	13.1	3	Plunge pool formed by weirs
26	1	Low gradient riffle	3.5	0.2	–	19.7	–	

Table 9. Stream survey results for Cherry Creek tributary A within the City of Duvall (continued).

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 2 (continued)								
27	5	Run	4.0	0.4	–	9.8	–	Channel full of large woody debris
28	1	Low gradient riffle	4.0	0.4	–	29.5	–	
29	11	Lateral scour pool-bedrock formed	4.0	0.6	1.1	9.8	3	Clay layer forms scour pool full of large woody debris
30	1	Low gradient riffle	4.0	0.3	–	16.4	–	
31	3	Cascade	5.0	0.4	–	150.9	–	Gradient increases to 10percent as channel cascades over boulders
32	1	Low gradient riffle	5.0	0.4	–	13.1	–	Short bench between cascades
33	3	Cascade	10.0	0.4	–	32.8	–	Wider channel cascading over boulders
34	2	High gradient riffle	6.0	0.3	–	32.8	–	Gradient decreases slightly
35	3	Cascade	5.0	0.2	–	105.0	–	Channel full of large woody debris
36	2	High gradient riffle	5.0	0.3	–	26.2	–	
37	13	Dammed pool	5.0	0.4	0.6	6.6	1	Weir forms dammed pool
38	2	High gradient riffle	5.0	0.3	–	75.4	–	
39	13	Dammed pool	5.0	0.5	0.8	9.8	1	Weir forms dammed pool
40	2	High gradient riffle	5.5	0.2	–	88.6	–	Channel full of large woody debris
41	8	Plunge pool	9.0	0.9	1.4	6.6	3	Plunge pool at culvert outlet below 4th Avenue
					Total	996.9		
Segment 3								
42	7	Trench/chute	2.0	0.2	–	150.9	–	2-foot-diameter CMP culvert underneath 4th Avenue with 1' drop at outlet
43	2	High gradient riffle	5.0	0.2	–	13.1	–	Incised channel full of large woody debris upstream of 4th Avenue
44	12	Lateral scour pool-boulder formed	5.0	0.5	0.8	6.6	1	Boulder forms scour pool
45	2	High gradient riffle	5.5	0.4	–	95.1	–	
46	1	Low gradient riffle	6.0	0.2	–	105.0	–	Recently installed bottomless arch culvert underneath 270th Place NE
47	8	Plunge pool	5.5	0.7	1.0	6.6	1	Plunge pool at base of waterfall formed by excavation of clay layer
48	3	Cascade	5.0	0.2	–	3.3	–	Waterfall over clay layer excavated to install culvert at 270th Place NE
49	2	High gradient riffle	5.0	0.4	–	88.6	–	Channel clogged with reed canarygrass and blackberries

Table 9. Stream survey results for Cherry Creek tributary A within the City of Duvall (continued).

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 3 (continued)								
50	5	Run	5.0	0.7	–	36.1	–	Run below culvert underneath private driveway
51	7	Trench/chute	1.0	0.2	–	29.5	–	1-foot-diameter concrete culvert underneath private driveway to 15926 4th Avenue
52	1	Low gradient riffle	5.5	0.4	–	45.9	–	
53	8	Plunge pool	5.0	0.5	0.8	6.6	2	Tree roots form weir and plunge pool
54	1	Low gradient riffle	4.5	0.4	–	32.8	–	
55	7	Trench/chute	2.0	0.3	–	39.4	–	2-foot-diameter concrete culvert underneath private driveway near Virginia Street
56	1	Low gradient riffle	5.0	0.3	–	23.0	–	Channel clogged with blackberries and willows
57	2	High gradient riffle	5.0	0.3	–	52.5	–	Recently restored channel lined with cobbles
58						250		Segment skipped due to access restriction, ends near Stewart Street
59	8	Plunge pool	5.0	0.9	1.3	13.1	2	Plunge pool at outlet of culvert that drains Rasmussen Lake
60	7	Trench/chute	2.0	0.2	–	49.2	–	2-foot-diameter CMP culvert underneath berm that contains Rasmussen Lake
61	1	Low gradient riffle	4.0	0.5	–	23.0	–	Short segment between culvert and Rasmussen Lake
					Total	1,070.3		
Segment 4								
62	13	Dammed pool	300	10	15	577.3	5	Rasmussen Lake acting as dammed pool
					Total	577.3		
Segment 5								
63	1	Low gradient riffle	2.0	0.2	–	52.5	–	Inlet channel to Rasmussen Lake that is lined with quarry spalls
64	7	Trench/chute	1.5	0.2	–	215.0	–	18-inch-diameter culvert underneath residential yards
65	1	Low gradient riffle	2.0	0.2	–	110.	–	Drainage ditch through residential yards that ends near NE 152nd Street
					Total	377.5		

[a] Habitat types are defined in Table 1.

Segment 4 consists of Rasmussen Lake (reach 62), which is a 577-foot-long and 300-foot-wide impoundment that averages 10 feet deep. This large pond provides functions such as floodwater storage, water quality improvement, fish and wildlife habitat, and groundwater recharge. In segment 4, the average wetted width ranges from 200 to 350 feet, the average wetted depth is assumed to be 10 feet, and the maximum pool depth is assumed to be 15 feet.

Segment 5 extends 378 feet from Rasmussen Lake to the headwaters near NE 152nd Street. Along the south shoreline of Rasmussen Lake there is a drainage ditch lined with quarry spalls (reach 63) that is the inlet channel. The flow is then culverted underneath residential lots for approximately 215 feet (reach 64). The channel then flows through drainage ditches up to NE 152nd Street, where it originates from groundwater seeps. The channel dimensions in segment 5 include an average wetted width ranging from 1.5 to 2.0 feet, and an average wetted depth of 0.2 feet.

Table 10 summarizes the stream survey data for Cherry Creek tributary A for the nine habitat types that were observed. This data indicates that the predominant habitat type consists of low gradient riffles, dammed pools, trench/chute, and high gradient riffles. The average channel dimensions of Cherry Creek tributary A (excluding Rasmussen Lake) ranges from 1.9 to 6 feet wide and 0.2 to 0.7 feet deep.

Table 10. Summary of habitat types in Cherry Creek tributary A within the City of Duvall.

Habitat Type	Average Width (ft.)	Average Depth (ft.)	Total Length (ft.)	Percentage of Length (percent)
1	3.80	0.32	864.4	28.5
2	5.25	0.30	472.3	15.6
3	6.00	0.36	321.5	10.6
5	4.80	0.44	78.6	2.6
7	1.92	0.22	546.3	18.0
8	5.79	0.70	59.1	2.0
11	3.50	0.67	29.4	1.0
12	5.00	0.50	6.6	0.2
13 [a]	5.40	0.50	649.5	21.5
		Total	3,027.7	100

[a] Average width and depth of dammed pools, excludes Rasmussen Lake.

Riparian Soils, Bank Stability, and Channel Morphology

The soil survey of King County identifies one soil type in the Cherry Creek tributary A study area, which includes Alderwood gravelly sandy loam on 6 to 15 percent slopes. The soils observed in the stream banks and streambed generally resemble these mapped soil types, although fill material exported from offsite is present in some locations. The clay layer exposed in portions of segments 1 through 3 is not identified on the soil survey map.

The stream banks are generally unstable in the Cherry Creek tributary A basin, especially in segments 1 through 3 due to artificial bed controls and steep gradient. Segment 1 (reaches 1-4) is characterized by an incised channel through an emergent wetland. The culvert underneath NE Cherry Valley Road, is acting as a bed control so the channel downstream of this culvert is downcutting to a clay layer. The channel in segment 2 has a steep gradient and is downcutting to create steep banks (1:1) that are 5 to 10 feet high and unstable. The channel is confined within steep ravine slopes that are eroding down to a clay layer that acts as a bed control and creates small waterfalls and plunge pools. However, bed controls formed by boulders, log weirs, and tree roots are controlling some of this downcutting. Within segment 3 the banks are also unstable but the lower gradient does not cause as much downcutting as observed in segment 2.

Channel morphology in Cherry Creek tributary A consists of a meandering channel confined by low banks. The thalwag meanders from one bank to the other as the channel changes direction and low flows are generally confined by the banks. The average gradient in segments 1 and 2 is 5 percent, while the gradient in segment 3 averages 2 percent, and the gradient in segments 4 and 5 is relatively flat. The width of the flood channel averages 10 feet, and the average depth of the flood channel ranges from 1 to 1.5 feet. Rasmussen Lake provides flood storage that moderates the scouring caused by stormwater runoff.

Substrate

Table 11 summarizes the substrate composition observed in Cherry Creek tributary A based on the length of each habitat type and percentage of the total length for the dominant and secondary substrates. The dominant stream channel substrate in Cherry Creek tributary A in descending order includes silt/organics, small gravel, and bedrock (clay). The secondary substrate types in descending order include sand, silt/organics, and small gravel. Spawning gravels in the second segment are judged fair, based on the amount of gravels and silt embeddedness.

Table 11. Substrate summary for Cherry Creek tributary A within the City of Duvall.

Substrate Code	Substrate Types	Dominant Coverage (ft.)	Secondary Coverage (ft.)	Dominant Coverage (percent)	Secondary Coverage (percent)
1	Bedrock	549.5	9.8	18.1	0.3
2	Silt/Organic	982.6	798.7	32.5	26.4
3	Sand	213.2	1,467.9	7.0	48.5
4	Small Gravel	701.7	524.9	23.2	17.3
5	Large Gravel	433.0	226.4	14.3	7.5
6	Cobbles	147.6	0	4.9	0
7	Boulders	0	0	0	0
	Totals	3,027.7	3,027.7	100	100

Large Woody Debris and Pool Quality

The amount of large woody debris (LWD) in the wetted channel of Cherry Creek tributary A varies throughout the basin. A total of 75 logs were observed for 3,028 feet of surveyed channel, and the majority of this LWD occurs in segments 2 and 3. Most of this LWD consisted of

moderately rotten deciduous logs, although there are some large cedar logs in the second segment. This LWD formed habitat features such as lateral logs, stranded logs, bridges, and weirs. The lack of LWD in segments 1 and 5, is possibly due to clearing of riparian vegetation that prevents recruitment.

Pool quality indexes (PQI) were assigned for 17 pools observed in the surveyed area of Cherry Creek tributary A. These pools consisted of 7 plunge pools, 3 lateral scour pools formed by clay bedrock, 1 lateral scour pool formed by a boulder, and 6 dammed pools. Most of these pools have widths greater than 10 percent of the average stream width, are relatively deep, and contained woody debris as cover. The maximum depths of these pools ranged between 0.6 and 1.4 feet, and most of the pools were rated with a PQI of 2. Overall, pools in the surveyed area provide fair rearing habitat but sediment deposition does not allow deep pools to develop. However, Rasmussen Lake has a maximum depth of 15 feet, a PQI of 5, and provides excellent rearing habitat.

Riparian Vegetation

The width of the riparian zone along Cherry Creek tributary A varies throughout the surveyed area, due to clearing by private property owners and adjacent land uses. Vegetation in segment 1, consists of emergent wetland species such as soft rush, reed canarygrass, and common velvetgrass (*Holcus lanatus*). Segment 2 has the widest, densest, and most diverse riparian vegetation in the study area. Segment 2 contains woody vegetation such as red alder, big leaf maple, western red cedar, Douglas fir, vine maple, salmonberry, willow, Himalayan blackberry, Indian plum, and red elderberry (*Sambucus racemosa*). Herbaceous vegetation in segment 2 includes reed canarygrass, slough sedge, creeping buttercup, piggy-back plant (*Tolmiea menziesii*), lady fern, skunk cabbage, and sword fern.

Segment 3 is bordered by the second widest riparian zone in the study area, which includes red alder, black cottonwood, Himalayan blackberry, salmonberry, willow, Japanese knotweed (*Polygonum cuspidatum*), and reed canarygrass. Riparian vegetation in segment 4 consists of an immature deciduous forest lining the shoreline of Rasmussen Lake. This shoreline vegetation includes red alder, big leaf maple, Himalayan blackberry, vine maple, Indian plum, willow, and salmonberry. There are two residential lots bordering Rasmussen Lake that contain lawn grass, ornamental trees and shrubs, and flower beds. Segment 5 is dominated by vegetation typical of residential lots such as lawn grass, ornamental trees and shrubs, and flower beds.

Population Estimates Based On Observations

No adult coho salmon were observed in Cherry Creek tributary A during the stream surveys. Although there is suitable habitat upstream of NE Cherry Valley Road, numerous migration barriers downstream of the project area may be preventing access to this stream.

Stream Survey Results for Cherry Creek Tributary B

The results of the King County Level 1 stream habitat inventory performed on Cherry Creek tributary B is discussed below. This includes: the results of the habitat survey; and a description

of the riparian soils, bank stability, channel morphology, substrate, large woody debris, pool quality, and riparian vegetation associated with Cherry Creek tributary B. The field data sheets completed for Cherry Creek tributary B are presented in Appendix B. Representative photographs taken of habitat in Cherry Creek tributary B are included in Appendix C. A summary of the culvert assessment data for Cherry Creek tributary B is provided in Appendix D.

Habitat Survey

The main stem of Cherry Creek tributary B has been divided into three segments (see Figure 5) based on channel gradient, migration barriers, substrate, and riparian zone conditions. The first segment (62 feet long) flows through emergent wetlands downstream of NE Cherry Valley Road. The second segment (279 feet long) extends upstream of NE Cherry Valley Road to a culvert underneath NE Rupard Road. The third segment (1,088 feet long) extends from the NE Rupard Road culvert to the City of Duvall corporate limits. A tributary (designated as Tributary 1) combines with the mainstem channel at the downstream side of NE Cherry Valley Road.

Table 12 lists the habitat types, channel dimensions, and pool quality index for Cherry Creek tributary B. A reach number is used to indicate the sequential order of habitats observed, of which a total of 14 reaches were recorded for a distance of 1,429 feet from NE Cherry Valley Road to the city limits.

The survey of Cherry Creek tributary B began in a pasture 62 feet downstream of NE Cherry Valley Road, which is outside the City of Duvall corporate limits. Proceeding upstream to the culvert underneath NE Cherry Valley Road, fish habitat in the lower 49 feet (reaches 1-5) consists of low gradient riffle run, and plunge pool habitat formed by a clay layer acting as bedrock. The channel is incised and narrow as it flows through an emergent wetland. At the downstream edge of NE Cherry Valley Road, there is a splash pad of quarry spalls (reach 6) at the outlet of two culverts. The mainstem channel passes underneath NE Cherry Valley Road in a 3-foot-diameter CMP (reach 7), while Tributary 1 passes through a 2-foot-diameter CMP. In this first segment, the average wetted width ranges from 2.0 to 9.0 feet, the average wetted depth ranges from 0.1 to 0.6 feet, and the maximum pool depth is 0.8 feet.

Segment 2 of Cherry Valley tributary B between NE Cherry Valley Road and NE Rupard Road has an undefined channel that braids through reed canarygrass and Himalayan blackberry, which limits fish migration. Immediately upstream of NE Cherry Valley Road, the channel cascades down a steep bank lined with quarry spalls to the culvert inlet (reach 8). The next 56 feet of channel consists of a low gradient riffle that braids around sediment deposits in an open field of reed canarygrass (reach 9). The channel continues to braid around sediment deposits as it enters a stand of red alder and Himalayan blackberry (reach 10). The culvert (2-foot-diameter plastic pipe) underneath NE Rupard Road is clogged with sediment (reach 11). Habitat in this second segment consists of low gradient riffles and cascades as the channel braids in multiple shallow rivulets. In segment 2, the average wetted width ranges from 2.0 to 5.0 feet and the average wetted depth ranges from 0.1 to 0.2 feet.

Table 12. Stream survey results for Cherry Creek tributary B within the City of Duvall.

Segment and Reach No.	Habitat Type No. [a]	Habitat Type	Average Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Length (ft.)	Pool Quality Index	Comments
Segment 1								
1	5	Run	2.0	0.5	–	6.6	–	Started survey in emergent wetland 62 feet downstream of NE Cherry Valley Road
2	1	Low gradient riffle	2.5	0.3	–	13.1	–	Incised channel through pasture of soft rush
3	8	Plunge pool	2.0	0.6	0.8	3.3	1	Plunge pool over clay layer
4	5	Run	3.0	0.6	–	9.8	–	
5	1	Low gradient riffle	3.0	0.3	–	16.4	–	
6	1	Low gradient riffle	9.0	0.1	–	13.1	–	Quarry spall splash pad at outlet of culvert so no plunge pool
					Total	62.3		
Segment 2								
7	7	Trench/chute	3.0	0.2	–	59.0	–	3-foot-diameter CMP culvert underneath NE Cherry Valley Road
8	3	Cascade	5.0	0.1	–	9.8	–	Cascades down steep bank covered with quarry spalls and blackberries
9	1	Low gradient riffle	4.0	0.1	–	55.8	–	Multiple braids through reed canarygrass in undefined channel
10	1	Low gradient riffle	4.5	0.2	–	39.4	–	Braided channel around gravel bars at outlet of culvert
11	7	Trench/chute	2.0	0.2	–	114.8	–	2-foot-diameter plastic culvert underneath NE Rupard Road that is clogged with sediment and most likely impassable.
					Total	278.8		
Segment 3								
12	2	High gradient riffle	3.5	0.2	–	550.7	–	High gradient riffle within ravine that is full of large woody debris
13	1	Low gradient riffle	3.0	0.2	–	36.7	–	Gradient levels for short segment
14	2	High gradient riffle	3.0	0.2	–	500.5	–	High gradient riffle that is full of large woody debris
					Total	1,087.9		

[a] Habitat types are defined in Table 1.

Segment 3 extends 1,088 feet from the NE Rupard Road culvert to the City of Duvall corporate limits. The channel in segment 3 meanders through a narrow floodplain between the steep ravine slopes and there are several locations where the channel down cuts to a clay layer that acts as bedrock. The channel has a high gradient (5-10 percent) that provides habitat consisting of low gradient riffles and high gradient riffles. There is abundant woody debris in the channel but pools do not form due to the excessive sediment transport that fills in any pools. The stream banks are eroded in several locations as the channel meanders between the ravine slopes. In segment 3, the average wetted width ranges from 3.0 to 3.5 feet and the average wetted depth is 0.2 feet.

Table 13 summarizes the stream survey data for Cherry Creek tributary B for the six habitat types that were observed. This data indicates that the predominant habitat type consists of low gradient riffles, high gradient riffles, and trench/chute. The average channel dimensions of Cherry Creek tributary B ranges from 2 to 5 feet wide and 0.2 to 0.6 feet deep.

Table 13. Summary of habitat types in Cherry Creek tributary B within the City of Duvall.

Habitat Type	Average Width (ft.)	Average Depth (ft.)	Total Length (ft.)	Percentage of Length (percent)
1	4.33	0.2	174.5	12.2
2	3.25	0.2	1,051.2	73.6
3	5.00	0.1	9.8	0.7
5	2.50	0.6	16.4	1.1
7	2.50	0.2	173.8	12.2
8	2.00	0.6	3.3	0.2
		Total	1,429	100

Riparian Soils, Bank Stability, and Channel Morphology

The soil survey of King County identifies one soil type in the Cherry Creek tributary B project area, which includes Alderwood gravelly sandy loam on 6 to 30 percent slopes. The soils observed in the stream banks and streambed generally resemble these mapped soil types, although fill material exported from offsite is present in some locations. The clay layer exposed in portions of segments 1 and 3 is not identified on the soil survey map.

The stream banks are generally unstable in the Cherry Creek tributary B basin, due to artificial bed controls, excessive sediment transport, and steep gradient. Segment 1 (reaches 1-4) consists of an incised channel that is downcutting through an emergent wetland. The culvert underneath NE Cherry Valley Road, is acting as a bed control so the channel downstream of this culvert is downcutting to a clay layer. The channel in segment 2 is relatively flat, so excessive sediment transport from upstream sources has caused deposition and braiding. Segment 3 has a steep gradient and is downcutting to create steep banks (1:1) that are 5 to 10 feet high and unstable. The channel is confined within steep ravine slopes that are eroding down to a clay layer that acts as a bed control.

Channel morphology in segment 1 of Cherry Creek tributary B consists of a meandering channel confined by low banks. The thalwag meanders from one bank to the other as the channel changes direction and low flows are generally confined by the banks. Channel morphology in segment 2 of Cherry Creek tributary B consists of a braided channel through alluvial deposits. Segment 3 is confined by the steep ravine slopes, so the channel meanders through a narrow floodplain. The average gradient in segments 1 and 2 is less than 2 percent, while the gradient in segment 3 averages 5 percent. The width of the flood channel averages 10 feet, and the average depth of the flood channel is approximately 1 foot.

Substrate

Table 14 summarizes the substrate composition observed in Cherry Creek tributary B based on the length of each habitat type and percentage of the total length for the dominant and secondary substrates. The dominant stream channel substrate in Cherry Creek tributary B in descending order includes small gravel, bedrock (clay), and sand. The secondary substrate types in descending order include sand, silt/organics, and small gravel. Spawning gravels in segment 3 are judged fair, based on the amount of gravel and silt embeddedness.

Table 14. Substrate summary for Cherry Creek tributary B within the City of Duvall.

Substrate Code	Substrate Types	Dominant Coverage (ft.)	Secondary Coverage (ft.)	Dominant Coverage (percent)	Secondary Coverage (percent)
1	Bedrock	173.8	0	12.2	0
2	Silt/Organic	0	229.6	0	16.1
3	Sand	62.4	1,192.8	4.3	83.4
4	Small Gravel	1,169.9	6.6	81.9	0.5
5	Large Gravel	22.9	0	1.6	0
6	Cobbles	0	0	0	0
7	Boulders	0	0	0	0
Totals		1,429	1,429	100	100

Large Woody Debris and Pool Quality

The amount of large woody debris (LWD) in the wetted channel of Cherry Creek tributary B varies throughout the basin. There are no logs in segments 1 and 2 possibly due to clearing of riparian vegetation that prevents recruitment. A total of 58 logs were observed in segment 3, and most of this LWD consisted of moderately rotten deciduous logs. This LWD formed habitat features such as lateral logs, bridges, and weirs.

A pool quality index was assigned for the only pool observed in the surveyed area of Cherry Creek tributary B (reach 3), which is outside of the project area. This plunge pool was formed by a clay layer acting as bedrock and did not contain any woody debris as cover. Overall, pools in the surveyed area are very scarce possibly due to sediment deposition that does not allow deep pools to develop.

Riparian Vegetation

The width of the riparian zone along Cherry Creek tributary B varies throughout the surveyed area, due to clearing by private property owners and adjacent land uses. Vegetation in the first segment, consists of emergent wetland species such as soft rush, reed canarygrass, and common velvetgrass. The second segment contains red alder, Himalayan blackberry, beaked hazelnut (*Corylus cornuta*), and reed canarygrass. The third segment is bordered by the widest and most diverse riparian zone in the project area, which includes red alder, bigleaf maple, black cottonwood, Himalayan blackberry, salmonberry, and Indian plum. Riparian vegetation in this third segment consists of an immature deciduous forest that is designated as a native growth protection area

Population Estimates Based On Observations

No adult coho salmon were observed in Cherry Creek tributary B during the stream surveys. Although there is suitable habitat upstream of NE Cherry Valley Road, numerous migration barriers downstream of the project area may be preventing access to this stream.

Fish Population Estimates

The fish species that possibly occur in the four streams within the City of Duvall, an estimate of their population size, and their life history requirements is discussed below. This information is based on observations made during the stream surveys, correspondence with WDFW biologists, and experience with similar streams in the area. Because electrofishing was not available as a method to assess the fish populations, the following estimates are qualitative in nature.

Based on direct observations, experience with fish species presence in similar Puget Sound lowland streams, and life history requirements (Wydoski and Whitney 1979) we have identified the following species that may occur in the four streams within the study area. This includes coho salmon (*Oncorhynchus kisutch*), resident rainbow and steelhead trout (*Oncorhynchus mykiss*), resident and sea-run cutthroat trout (*Oncorhynchus clarki*), sculpins (*Cottus* sp.), western brook lamprey (*Lampetra richardsoni*), and three-spine stickleback (*Gasterosteus aculeatus*).

The WDFW has also confirmed the possible presence of coho salmon, steelhead trout, and cutthroat trout in the four streams within the City of Duvall (Wenger 2002 personal communication). Data collected by Washington Trout during their culvert assessments on Cherry Creek downstream of the project area indicate that coho salmon, rainbow trout, and cutthroat trout are present (Washington Trout 2001).

Population Estimates Based On Observations

Adult coho salmon were observed spawning in Thayer Creek during the stream survey conducted on November 27, 2001. Herrera biologists observed eight live fish, six carcasses, and

four redds. We estimate a total population size of approximately 30 adult coho salmon using Thayer Creek based on the assumption that half of the fish using the stream were observed. These fish were observed between an access road culvert (reach 26) and the upstream side of NE 143rd Place (reach 59). The habitat downstream of the access road is not suitable for spawning (low gradient and lack of gravel) and the habitat upstream of NE 143rd Place precludes spawning (migration barriers and lack of gravel).

Adult coho salmon were observed spawning in Coe-Clemons Creek during the stream surveys conducted on November 26 and 29, 2001. Herrera biologists observed six live fish, seven carcasses, and two redds. We estimate a total population size of approximately 25 adult coho salmon using Coe-Clemons Creek based on the assumption that half of the fish using the stream were observed. These fish were observed between the wetland mitigation site (reach 14) and the upstream side of Highway 203 (reach 35). The habitat downstream of the mitigation site is not suitable for spawning (low gradient and lack of gravel) and migration barriers upstream of Highway 203 may limit spawning.

No adult coho salmon were observed in Cherry Creek tributaries A and B during the stream surveys. Although there is suitable habitat upstream of NE Cherry Valley Road, numerous migration barriers downstream of the project area may be preventing access to both of these streams.

Life History Requirements

Coho salmon adults begin entering the Snoqualmie River in October and spawning begins in November and continues into January. Adult coho salmon enter Thayer and Coe-Clemons Creek to spawn during November and December. Smoltification and seaward migration of coho occurs between April and May (McMahon 1983).

Winter-run steelhead adults migrate upstream in the Snoqualmie River between December and May and may spawn in Thayer and Coe-Clemons Creeks anywhere between December to February. The juvenile steelhead trout undergo smoltification and outmigrate to the ocean between April and June. Resident rainbow trout migrate entirely within freshwater systems.

Sea-run cutthroat trout enter the streams as adults from mid-winter to early spring. They spawn between January and late June with peak spawning occurring between March and May. Typically, two-year old smolts of sea-run cutthroat trout migrate to the sea between mid-April and mid-May and sometimes as late as June. Resident cutthroat trout migrate entirely within freshwater systems. Resident cutthroat trout spawn in Thayer and Coe-Clemons Creek in April and May. Generally, cutthroat trout spawn in small tributaries at the upper limits of spawning and rearing sites for coho salmon, steelhead, and rainbow trout.

Potential Restoration Projects

Fish habitat within these four streams in the City of Duvall have varying levels of degradation from past land uses. During the stream surveys and culvert assessments, Herrera biologists made numerous observations of poor habitat conditions that could be corrected. These habitat conditions include migration barriers and the lack or poor quality of spawning and rearing habitat. This preliminary list of restoration projects will be reassessed during the second phase of this project and described in much greater detail in the *Conceptual Restoration Plan for the City of Duvall*.

Thayer Creek

Table 15 lists the potential restoration projects that could be undertaken in Thayer Creek. This table describes the location of each project, the relative priority for completing each project, and the rationale for selecting these projects. These restoration projects fall into three main priorities based on improving conditions sequentially from the mouth to the headwaters.

- The top priority for restoration in Thayer Creek involves removing migration barriers and improving riparian zone habitat in segments 1 through 3. These migration barriers include two culverts (access road culvert downstream of abandoned railroad berm and access road culvert upstream of abandoned railroad berm), the high gradient channel in segment 3, and the incised channel at the Snoqualmie River confluence. Although coho salmon are already accessing spawning habitat in segment 3, the migration barriers are limiting their potential. Enhancing rearing habitat in segments 1 and 2 will also improve the survival of juveniles.
- The second priority for restoration in Thayer Creek involves removing migration barriers and restoring the channel in segments 4 and 5. These migration barriers include the culverts underneath Highway 203 and the berm at the first pond. Removing the berm at the first pond and restoring this area will extend potential spawning habitat up to the second pond.
- The third priority for restoration in Thayer Creek involves removing migration barriers and improving rearing habitat in segments 5 and 6. These migration barriers include the culverts through the berms at second and third ponds. This will allow juvenile fish to utilize rearing habitat in these ponds, and in the headwaters.

Coe-Clemons Creek

Table 16 lists the potential restoration projects that could be undertaken in Coe-Clemons Creek. These restoration projects fall into five main priorities based on reducing a sediment source and improving conditions sequentially from the mouth to the headwaters.

Table 15. Potential restoration projects within Thayer Creek in the City of Duvall.

Segment No.	Reach No.	Potential Restoration Action	Priority	Rationale	Photographs
1	1-12	Option A: Restore segment 1 by a creating new channel, stabilizing the stream banks, and improving riparian vegetation. This requires excavation to create a wider channel with more sinuosity, and regrading the stream banks to create 4:1 slopes that are stable during flooding by the Snoqualmie River. Install large woody debris and boulders as bed controls to lower the gradient and to provide juvenile rearing habitat. Plant native tree, shrub, and herbaceous species on the reconfigured stream banks.	3	The incised stream banks and narrow channel in this segment provides poor habitat for adult migration and juvenile rearing	1-4
		Option B: Stabilize the stream banks by removing invasive species and planting native vegetation.			
1	13	Option A: Remove 26-inch-diameter culvert underneath access road, regrade the stream banks, and revegetate the disturbed area. This requires excavation to remove the culvert and regrading of the stream banks to create 4:1 slopes. Revegetate the reconfigured stream banks by planting native tree, shrub, and herbaceous species.	1	This clogged culvert is a partial migration barrier to salmon and it acts as a bed control that contributes to downcutting.	5-6
		Option B: Remove the existing culvert and provide a bridge over the channel to maintain access to the farm fields. This bridge could be constructed using ecology blocks and a truck trailer or pre-fabricated span. Stabilize the stream banks by planting native tree, shrub, and herbaceous species.			
2	16-25	Improve riparian zone along stream banks in segment 2. This requires selectively removing invasive species and planting native tree, shrub, and herbaceous species along the stream banks.	4	Portions of the riparian zone in this segment lack an overstory of trees and shrubs.	10-12
2	26	Option A: Remove 26-inch-diameter culvert underneath access road, regrade the stream banks, and revegetate the disturbed area. This requires excavation to remove the culvert and regrading of the stream banks. Revegetate the reconfigured stream banks by planting native tree, shrub, and herbaceous species.	5	This culvert is a partial migration barrier to salmon.	13-14
		Option B: Remove the existing culvert and provide a bridge over the channel to maintain access. This bridge could be constructed using ecology blocks and a truck trailer or other pre-fabricated span. Stabilize the stream banks by planting native tree, shrub, and herbaceous species.			
3	33	Option A: Stabilize tributary 1 stream channel between the culvert outfall and mainstem. This requires reconfiguring the stream banks to create 4:1 slopes, lining the channel with gravel substrate, and revegetating the reconfigured stream banks by planting native tree, shrub, and herbaceous species.	14	The culvert outfall is eroding the tributary channel and contributing sediment to the mainstem.	17
		Option B: Stabilize the tributary channel by armoring with quarry spalls to prevent further erosion.			
3	34-44	Provide bed controls to improve adult migration in segment 3. This requires installing log and boulder weirs in several high gradient areas where partial migration barriers occur.	2	The stream cascades over existing bed controls but the gradient is too high or plunge pools are not present.	20-21

Table 15. Potential restoration projects within Thayer Creek in the City of Duvall (continued).

Segment No.	Reach No.	Potential Restoration Action	Priority	Rationale	Photographs
3	49	Improve riparian vegetation in this reach that is limiting adult spawning and migration. This requires selectively removing invasive species and planting native tree, shrub, and herbaceous species along the stream banks.	7	The channel is clogged by reed canarygrass, which restricts migration through this reach.	23
4	51	Replace 2-foot-diameter culvert underneath Highway 203 that is restricting adult migration. This requires excavation to remove the existing culvert and replacing it with a bottomless arch culvert.	6	The slope of this culvert may be a partial migration barrier to adult salmon.	25-26
4	53-55	Enhance riparian zone along stream banks in the pasture between Highway 203 and NE 143rd Place. This requires planting native tree, shrub, and herbaceous species along the stream banks.	8	The lack of a forested riparian zone is degrading water quality and limiting juvenile rearing habitat.	27-28
4	60-62	Remove riparian vegetation in this reach that is limiting adult spawning and migration. This requires selectively removing shrubs obstructing the stream channel, and lining the channel with spawning gravels.	12	The channel is clogged with shrubs that prevents spawning gravel accumulation and restricts migration through this reach.	32-33
5	63-66	Option A: Remove the farm pond and restore this area by creating a new channel, stabilizing the stream banks, and improving riparian vegetation. This requires excavation to remove the berm around the farm pond and creating a new channel. The elevation differences in this area will require installing bed controls to lower the gradient, and regrading the stream banks to create 4:1 slopes. Plant native tree, shrub, and herbaceous species on the reconfigured stream banks. Option B: Replace the culvert with a larger diameter pipe with a level slope.	10	The culvert through the farm pond berm is a migration barrier, the lack of a forested riparian zone is degrading water quality, and there is no spawning habitat.	34-37
5	68	Restore berm that contains second pond by installing a new culvert and filling the trench that breaches the berm. This will require removing the existing obsolete culvert and replacing it with a bottomless arch culvert.	11	The existing culvert and the trench that breaches the berm is a partial migration barrier and is contributing sediment to downstream habitat.	39-40
5	70-72	Remove sediment deposits downstream of Safeway Plaza wetland mitigation site and reline the channel with gravel substrate. This will require selectively excavating sediment deposits interspersed with the existing vegetation, and lining the stream channel with gravels.	9	Runoff from the mitigation site has clogged the channel with sediment, which is causing a partial migration barrier and is filling in the second pond.	43-44
6	78-79	Option A: Remove the third pond and restore this area by creating a new channel, stabilizing the stream banks, and improving riparian vegetation. This requires excavation to remove the berm around the third pond and creating a new channel. The elevation differences in this area will require installing bed controls to lower the gradient, and regrading the stream banks to create 4:1 slopes. Plant native tree, shrub, and herbaceous species on the reconfigured stream banks. Option B: Replace the culvert with a larger diameter pipe with a level slope	13	The culvert through the berm is a migration barrier.	52-53

Table 16. Potential restoration projects within Coe-Clemons Creek in the City of Duvall.

Segment No.	Reach No.	Potential Restoration Action	Priority	Rationale	Photographs
1	1-2	Option A: Restore segment 1 by creating a wider channel, stabilizing the stream banks, and improving riparian vegetation. This requires excavation to create a wider channel cross-section, and regrading the stream banks to create 4:1 slopes that are stable during flooding by the Snoqualmie River. Install large woody debris and boulders as bed controls to lower the gradient and to provide juvenile rearing habitat. Plant native tree, shrub, and herbaceous species on the reconfigured stream banks. Option B: Stabilize the stream banks by removing invasive species and planting native vegetation.	5	The incised stream banks and narrow channel in this segment provides poor habitat for adult migration and juvenile rearing	57-59
1	7-9	Improve fish passage through the culvert underneath the access road into McCormick Park. This requires removing quarry spalls and creating a plunge pool at the culvert outlet, and removing quarry spalls at the culvert inlet.	7	Adult migration through this culvert is limited by the lack of deep pools at the entrance and exit of the pipe.	60-62
2	11	Replace culvert underneath abandoned railroad berm that is restricting adult migration. This requires excavation to remove the existing culvert and replacing it with a bottomless arch culvert.	3	Beavers have blocked the inlet to the culvert and sediment has accumulated inside the pipe, which restricts migration.	64-65
3	14-17	Restore channel through wetland mitigation site that is limiting adult migration. This involves creating a new channel and improving riparian vegetation. Install large woody debris and boulders as bed controls to lower the gradient and to provide juvenile rearing habitat. Improve riparian vegetation by selectively removing invasive species and planting native tree, shrub, and herbaceous species along the stream banks.	2	The channel is clogged by sediment and reed canarygrass, which restricts migration through this reach.	70-72
3	18-27	Remove sediment deposits and reline the channel with gravel substrate to improve adult migration. This will require selectively excavating sediment deposits interspersed with the existing vegetation, and lining the stream channel with gravels.	6	Sediment from a slump upstream of this area has clogged the channel, which is causing a partial migration barrier.	75-78
3	28	Replace the culvert underneath Highway 203 that is restricting adult migration. This requires excavation to remove the existing culvert and replacing it with a bottomless arch culvert.	4	Sediment from a slump upstream of this area has clogged the culvert, which is causing a partial migration barrier.	79-80
4	36	Remove collapsed wooden bridge that is restricting adult migration. This requires removing the woody debris jam that is obstructing the channel.	8	The channel is clogged by sediment and woody debris, which restricts migration through this reach.	84-85

Table 16. Potential restoration projects within Coe-Clemons Creek in the City of Duvall (continued).

Segment No.	Reach No.	Potential Restoration Action	Priority	Rationale	Photographs
4	58	Option A: Stabilize the stream banks that have slumped into the channel and are contributing a large volume of sediment to downstream reaches. Reconfigure the stream channel by removing sediment and woody debris jams, and revegetate the disturbed area with riparian vegetation. This requires excavation to create a wider channel cross-section, and regrading the stream banks to create 4:1 slopes that are stable. Install large woody debris and boulders as bed controls to lower the gradient and to prevent further downcutting. Plant native tree, shrub, and herbaceous species on the reconfigured stream banks. Option B: Place logs at the toe of the slumped bank to prevent further erosion. Cover the eroded banks with coir fabric and plant with native tree, shrub, and herbaceous species.	1	Sediment from the slump has clogged the channel, and is degrading downstream habitat.	97-100
4	70-72	Stabilize the stream banks where a clay layer is contributing sediment to downstream reaches.	15	Scouring of the clay layer is degrading spawning habitat by contributing fine-grained sediment.	104-105
4	73	Remove concrete flume that has collapsed into channel and is restricting adult migration. This requires removing the concrete debris jam that is obstructing the channel.	9	The channel is clogged by sediment and concrete debris, which restricts migration through this reach.	107-108
5	76	Improve fish passage through the culvert underneath NE 3rd Avenue by removing a log from the culvert outlet and creating a plunge pool. This will require installing large woody debris and boulders as bed controls to create a plunge pool at the culvert outlet.	10	The culvert is a migration barrier to fish using upstream habitat.	110-111
5	88-90	Improve fish passage through the culverts draining the stormwater detention pond near NE 3rd Place by creating a plunge pool. This will require installing large woody debris and boulders as bed controls to create a plunge pool at the culvert outlet.	11	These culverts are a migration barrier to fish using upstream habitat.	118-119
5	92	Improve fish passage through the culvert near NE 3rd Place by reducing water velocities at the culvert inlet. This will require installing large woody debris and boulders as bed controls to create a resting pool at the culvert inlet.	12	Adult migration through this culvert is limited by the lack of a pool at the exit of the pipe.	121-122
5	98	Improve fish passage through the culverts underneath Miller Street by reducing water velocities at the culvert inlet. This will require installing large woody debris and boulders as bed controls to create a resting pool at the culvert inlet.	13	Adult migration through these culverts is limited by the lack of a pool at the exit of the pipe.	124-125
6	100-135	Improve fish passage through the 12 culverts underneath private driveways along NE Miller Street by reducing water velocities. This will require installing large woody debris and boulders as bed controls to create resting pools at the culverts outlet and inlet.	14	Adult migration through these culverts is limited by the lack of pools at the entrance and exit of the pipes.	126-139

- The top priority for restoration in Coe-Clemons Creek is to stabilize the large slump in segment 4 that is contributing sediment and degrading downstream habitat. This source of sediment needs to be stabilized because the sediment will continue to create migration barriers downstream in segment 3.
- The second priority involves removing migration barriers and improving habitat in segment 3. The sediment from the large slump has clogged the culvert underneath Highway 203 and created a braided channel in the Copper Hill Square wetland mitigation site, which presents a migration barrier to adult salmon.
- The third priority for restoration in Coe-Clemons Creek involves removing migration barriers in the first and second segments. The migration barriers include a beaver dam that has clogged the culvert underneath the abandoned railroad berm, and the incised channel at the Snoqualmie River confluence. Removal of these barriers will improve adult migration from the Snoqualmie River to spawning habitat in segment 4.
- The fourth priority involves removing migration barriers in segments 4 and 5 so adult salmon can access more spawning habitat. These migration barriers include a collapsed wooden bridge and concrete flume in segment 4, and the culverts underneath NE 3rd Avenue and NE Kennedy Drive.
- The fifth priority involves removing migration barriers in segments 5 and 6 so both adult and juvenile salmon can access habitat in the upper reaches. These migration barriers include the culverts at the stormwater detention pond and along NE Miller Street.

Cherry Creek Tributary A

Table 17 lists the potential restoration projects that could be undertaken in Cherry Creek tributary A. These restoration projects fall into two main priorities based on removing migration barriers and improving conditions sequentially from the city limits to the headwaters.

- The top priority involves removing migration barriers in segments 1 and 2 so adult salmon can access spawning habitat within the City of Duvall. These migration barriers include the culverts underneath NE Cherry Valley Road and NE 4th Avenue, the braided channel immediately upstream of NE Cherry Valley Road, and the high gradient channel in segment 2. Suitable spawning habitat exists within segment 2 but adults are not accessing this area due to migration barriers.
- The second priority involves removing migration barriers and improving habitat in segment 3. These migration barriers include three culverts between NE 4th Avenue and Rasmussen Lake, and a cascade created near 270th Place NE.

Table 17. Potential restoration projects within Cherry Creek tributary A in the City of Duvall.

Segment No.	Reach No.	Potential Restoration Action	Priority	Rationale	Photographs
1	5-6	Improve fish passage through the culvert underneath NE Cherry Valley Road by creating a plunge pool. This will require installing large woody debris and boulders as bed controls to create a plunge pool at the culvert outlet.	1	This culvert is a migration barrier to fish using upstream habitat.	148-150
1	8	Improve riparian vegetation in this reach that is limiting adult spawning and migration. This requires selectively removing invasive species and planting native tree, shrub, and herbaceous species along the stream banks.	2	The channel is clogged by reed canarygrass, which restricts migration through this reach.	151-152
2	31-41	Provide bed controls to improve adult migration in this segment. This requires installing log and boulder weirs in several high gradient areas where partial migration barriers occur.	4	The stream cascades over existing bed controls but the gradient is too high or plunge pools are not present.	161-168
3	42	Replace the culvert underneath NE 4th Avenue that is restricting adult migration. This requires excavation to remove the existing culvert and replacing it with a bottomless arch culvert. Install large woody debris and boulders as bed controls to create a plunge pool at the culvert outlet.	3	The slope of this culvert and the outfall drop is a migration barrier to adult salmon.	170-171
3	48	Provide bed controls to improve adult migration at the upstream end of the 270th Place NE culvert. This requires installing log and boulder weirs through a cascade where a migration barrier occurs.	5	The stream cascades over a clay layer and the gradient is too high.	175
3	51	Replace the culvert underneath a private driveway to 15926-NE 4th Avenue that is restricting adult migration. This requires excavation to remove the existing culvert and replacing it with a bottomless arch culvert.	6	This culvert is undersized and may be a migration barrier to adult salmon.	177-178
3	55	Replace the culvert underneath a driveway to the old water tower that is restricting adult migration. This requires excavation to remove the existing culvert and replacing it with a bottomless arch culvert.	8	This culvert may be a migration barrier to adult salmon.	180-181
3	60	Replace the culvert underneath the berm containing Rasmussen Lake that is restricting adult migration. This requires excavation to remove the existing culvert and replacing it with a bottomless arch culvert. Install large woody debris and boulders as bed controls to create a plunge pool at the culvert outlet.	7	The slope of this culvert and the outfall drop is a migration barrier to adult salmon.	186-187

Cherry Creek Tributary B

Table 18 lists the potential restoration projects that could be implemented in Cherry Creek tributary B. These restoration projects are based on removing migration barriers and improving conditions sequentially from the city limits to the headwaters.

- The top priority involves removing migration barriers in segments 1 and 2 so adult salmon can access spawning habitat within the City of Duvall. These migration barriers include the culverts underneath NE Cherry Valley Road and NE Rupard Road, and the braided channel immediately upstream of NE Cherry Valley Road. Adequate spawning habitat exists within segment 3 but adults are not accessing this area due to migration barriers.

Table 18. Potential restoration projects within Cherry Creek tributary B in the City of Duvall.

Segment No.	Reach No.	Potential Restoration Action	Priority	Rationale	Photographs
1	6-8	Improve fish passage through the culvert underneath NE Cherry Valley Road by creating pools at both ends. This requires removing quarry spalls and creating a plunge pool at the culvert outlet, and removing quarry spalls at the culvert inlet. Install large woody debris and boulders as bed controls to create a plunge pool at the culvert outlet.	1	Adult migration through this culvert is limited by the lack of deep pools at the entrance and exit of the pipe.	192-194
2	9-10	Remove sediment deposits in the channel between NE Cherry Valley Road and NE Rupard Road that is limiting adult spawning and migration. This will require selectively excavating sediment deposits interspersed with the existing vegetation, and lining the stream channel with gravels. Enhance riparian vegetation in this reach by selectively removing invasive species and planting native tree, shrub, and herbaceous species along the stream banks.	3	The channel is clogged by sediment and reed canarygrass, which restricts migration through this reach.	195
2	11	Replace the culvert underneath NE Rupard Road that is restricting adult migration. This requires excavation to remove the existing culvert and replacing it with a bottomless arch culvert.	2	Sediment from erosion in upstream reaches has clogged the culvert with sediment, which is causing a partial migration barrier.	196-197

References

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Washington D.C. U.S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services.

DNR. 1995. Aerial photographs of the City of Duvall area taken in 1995. Washington Department of Natural Resources, Olympia, Washington.

DNR. 2001. Forest practice base map of the Snoqualmie River and streams within the City of Duvall. Washington Department of Natural Resources, Olympia, Washington.

Duvall, City of. 1991. Sensitive areas map. City of Duvall, Washington.

Duvall, City of. 2000. Zoning area map. City of Duvall, Washington.

FEMA. 1995. Flood insurance rate maps of the Snoqualmie River area within the City of Duvall. Panels 115, 401 and 405 of 1725 for the King County incorporated areas. Federal Emergency Management Agency.

King County. 1990. Sensitive areas map folio. King County Environmental Division-Parks, Planning, and Resource Department.

King County. 1991a. Wetlands Inventory. Volume 3 North 1990. King County Environmental Division-Parks, Planning, and Resource Department.

King County. 1991b. Stream survey report criteria for Level I surveys. King County Building and Land Development Division-Parks, Planning, and Resources Department.

McCain, M., D. Fuller, L. Decker, and K. Overton. 1990. Stream habitat classification and inventory procedures for Northern California. Technical Bulletin No. 1. Prepared for the U.S. Forest Service, Region 5, Fish Habitat Relationships Program.

McMahon, Thomas E. 1983. Habitat suitability index models: coho salmon. Publication #FWS/OBS-82/10.49. U.S. Department of the Interior, Fish and Wildlife Service.

NMFS. 2002. Agency correspondence on the presence of endangered or threatened anadromous fish species in the project site. National Marine Fisheries Service, Environmental and Technical Services Division.

U.S. COE. 1987. Corps of Engineers wetlands delineation manual. Technical report Y-87-1, U.S. Army Corps of Engineers Waterway Experiment Station, Vicksburg, Mississippi.

USDA. 1973. Soil survey of King County, Washington. U.S. Department of Agriculture, Soil Conservation Service, in cooperation with the Washington State Agricultural Experiment Station. Government Printing Office, Washington, D.C.

USDA. 1988. Hydric soils of the state of Washington. U.S. Department of Agriculture, Soil Conservation Service.

USFS. 1987. Methods for evaluating riparian habitats with applications to management. U.S. Department of Agriculture, Forest Service General Technical Report INT-221.

USFWS. 1973. National wetland inventory map. Monroe quadrangle. 1:24,000. U.S. Fish and Wildlife Service.

USFWS. 1983. National wetland inventory map. Carnation quadrangle. 1:24,000. U.S. Fish and Wildlife Service.

USFWS. 2002. Agency correspondence on the presence of endangered, threatened, and candidate species of wildlife near the project site. U.S. Fish and Wildlife Service, Ecological Services Division.

USGS. 1968. Topographic map. Carnation quadrangle. 1:24,000. U.S. Geological Survey.

USGS. 1973. Topographic map. Monroe quadrangle. 1:24,000. U.S. Geological Survey.

Washington Trout. 2001. Culvert assessment and population estimates for streams within the City of Duvall.

WDF. 1975. A catalog of Washington streams and salmon utilization. Volume 1: Puget Sound Region. Washington Department of Fisheries.

WDFW. 2000. Fish passage barrier and surface water diversion screening assessment and prioritization manual. Prepared by the Salmonid Screening, Habitat Enhancement, and Restoration (SSHEAR) Section. Washington Department of Fish and Wildlife Habitat Program, Environmental Restoration Division, Olympia.

WDFW. 2001. Agency correspondence with listing of federal and state agency status of priority habitat and species. Washington Department of Fish and Wildlife, Priority Species and Habitat Program.

Wenger, M. March 20, 2002. Personal communication (telephone conversation with Doug Gresham, Herrera Environmental Consultants regarding fish presence in the project area). Washington Department of Fish and Wildlife.

Wydoski, R.S. and R.R. Whitney. 1979. Inland fishes of Washington. Seattle, WA, and London. University of Washington Press. 220 p.